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SOME CHEMICAL ASPECTS OF LIFE[1]

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I

THE British Association returns to Leicester with assurance of a welcome as warm as that received twenty-six years ago, and of hospitality as generous. The renewed invitation and the ready acceptance speak of mutual appreciation born of the earlier experience. Hosts and guests have to-day reasons for mutual congratulations. The association on its second visit finds Leicester altered in important ways. It comes now to a city duly chartered and the seat of a bishopric. It finds there a center of learning, many fine buildings which did not exist on the occasion of the first visit and many other evidences of civic enterprise. The citizens of Leicester, on the other hand, will know that since they last entertained it the association has celebrated its centenary, has four times visited distant parts of the Empire and has maintained unabated through the years its useful and important activities.

In 1907 the occupant of the presidential chair was, as you know, Sir David Gill, the eminent astronomer who, unhappily, like many who listened to his address, is with us no more. Sir David dealt in that address with aspects of science characterized by the use of very exact measurement. The exactitude which he prized and praised has since been developed by modern physics and is now so great that its methods have real esthetic beauty. In contrast I have to deal with a branch of experimental science which, because it is concerned with living organisms, is in respect of measurement on a different plane. Of the very essence of biological systems is an ineludable complexity, and exact measurement calls for conditions here unattainable. Many may think, indeed, though I am not claiming it here, that in studying life we soon meet with aspects which are non-metrical. I would

[1] The presidential address before the British Association for the Advancement of Science, Leicester, September 6.

have you believe, however, that the data of modern biochemistry, which will be the subject of my remarks, were won by quantitative methods fully adequate to justify the claims based upon them.

Though speculations concerning the origin of life have given intellectual pleasure to many, all that we yet know about it is that we know nothing. Sir James Jeans once suggested, though not with conviction, that it might be a disease of matter, a disease of its old age! Most biologists, I think, having agreed that life's advent was at once the most improbable and the most significant event in the history of the universe, are content for the present to leave the matter there.

We must recognize, however, that life has one attribute that is fundamental. Whenever and wherever it appears the steady increase of entropy displayed by all the rest of the universe is then and there arrested. There is no good evidence that in any of its manifestations life evades the second law of thermodynamics, but in the downward course of the energy-flow it interposes a barrier and dams up a reservoir which provides potential for its own remarkable activities. The arrest of energy degradation in living nature is indeed a primary biological concept. Related to it, and of equal importance, is the concept of organization.

It is almost impossible to avoid thinking and talking of life in this abstract way, but we perceive it, of course, only as manifested in organized material systems, and it is in them we must seek the mechanisms which arrest the fall of energy. Evolution has established division of labor here. From far back the wonderfully efficient functioning of structures containing chlorophyll has, as every one knows, provided the trap which arrests and transforms radiant energy —fated otherwise to degrade—and so provides power for nearly the whole living world. It is impossible to believe, however, that such a complex mechanism was associated with life's earliest stages. Existing organisms illustrate what was perhaps an earlier method. The so-called autotrophic bacteria obtained energy for growth by the catalyzed oxidation of materials belonging wholly to the inorganic world; such as sulfur, iron or ammonia, and even free hydrogen. These organisms dispense with solar energy, but they have lost in the evolutionary race because their method lacks economy. Other existing organisms, certain purple bacteria, seem to have taken a step towards greater economy, without reaching that of the green cell. They dispense with free oxygen and yet obtain energy from the inorganic world. They control a process in which carbon dioxide is reduced and hydrogen sulfide simultaneously oxidized. The molecules of the former are activated by solar energy which their pigmentary equipment enables these organisms to arrest.

Are we to believe that life still exists in association with systems that are much more simply organized than any bacterial cell? The very minute filter-passing viruses which, owing to their causal relations with disease, are now the subject of intense study, awaken deep curiosity with respect to this question. We can not yet claim to know whether or not they are living organisms. In some sense they grow and multiply, but, so far as we yet know with certainty, only when inhabitants of living cells. If they are nevertheless living, this would suggest that they have no independent power of obtaining energy and so can not represent for us the earliest forms in which life appeared. At present, however, judgment on their biological significance must be suspended. The fullest understanding of all the methods by which energy may be acquired for life's processes is much to be desired.

In any case every living unit is a transformer of energy, however acquired, and the science of biochemistry is deeply concerned with these transformations. It is with aspects of that science that I am to deal, and if to them I devote much of my address my excuse is that since it became a major branch of inquiry biochemistry has had no exponent in the chair I am fortunate enough to occupy.

As a progressive scientific discipline it belongs to the present century. From the experimental physiologists of the last century it obtained a charter, and, from a few pioneers of its own, a promise of success; but for the furtherance of its essential aim that century left it but a small inheritance of facts and methods. By its essential or ultimate aim I myself mean an adequate and acceptable description of molecular dynamics in living cells and tissues.

II

When this association began its history in 1831 the first artificial synthesis of a biological product was, as you will remember, but three years old. Primitive faith in a boundary between the organic and the inorganic which could never be crossed was only just then realizing that its foundations were gone. Since then, during the century of its existence, the association has seen the pendulum swing back and forth between frank physicochemical conceptions of life and various modifications of vitalism. It is characteristic of the present position and spirit of science that sounds of the long conflict between mechanists and vitalists are just now seldom heard. It would almost seem, indeed, that tired of fighting in a misty atmosphere each has retired to his tent to await with wisdom the light of further knowledge. Perhaps, however, they are returning to the fight disguised as Determinist and Indeterminist, respectively. If so, the outcome will be of great interest. In any case I

feel fortunate in a belief that what I have to say will not, if rightly appraised, raise the old issues. To claim, as I am to claim, that a description of its active chemical aspects must contribute to any adequate description of life is not to imply that a living organism is no more than a physicochemical system. It implies that at a definite and recognizable level of its dynamic organization an organism can be logically described in physicochemical terms alone. At such a level indeed we may hope ultimately to arrive at a description which is complete in itself, just as descriptions at the morphological level of organization may be complete in themselves. There may be yet higher levels calling for discussion in quite different terms.

I wish, however, to remind you of a mode of thought concerning the material basis of life, which, though it prevailed when physicochemical interpretations were fashionable, was yet almost as inhibitory to productive chemical thought and study as any of the claims of vitalism. This was the conception of that material basis as a single entity, as a definite though highly complex chemical compound. Up to the end of the last century and even later the term "protoplasm" suggested such an entity to many minds. In his brilliant presidential address at the association's meeting at Dundee twenty-two years ago, Sir Edward Sharpey-Schafer, after remarking that the elements composing living substances are few in number, went on to say: "The combination of these elements into a colloid compound represents the physical basis of life, and when the chemist succeeds in building up this compound it will, without doubt, be found to exhibit the phenomena which we are in the habit of associating with the term 'life.'" Such a compound would seem to correspond with the "protoplasm" of many biologists, though treated perhaps with too little respect. The presidential claim might have seemed to encourage the biochemist, but the goal suggested would have proved elusive, and the path of endeavor has followed other lines.

So long as the term "protoplasm" retains a morphological significance, as in classical cytology, it may be even now convenient enough, though always denoting an abstraction. In so far, however, as the progress of metabolism with all the vital activities which it supports was ascribed in concrete thought to hypothetical qualities emergent from a protoplasmic complex in its integrity or when substances were held to suffer change only because in each living cell they are first built up, with loss of their own molecular structure and identity, into this complex, which is itself the inscrutable seat of cyclic change, then serious obscurantism was involved.

Had such assumptions been justified the old taunt that when the chemist touches living matter it immediately becomes dead matter would also have been justified. A very distinguished organic chemist, long since dead, said to me in the late eighties: 'The chemistry of the living? That is the chemistry of protoplasm; that is superchemistry; seek, my young friend, for other ambitions."

Research, however, during the present century, much of which has been done since the association last met in Leicester, has yielded knowledge to justify the optimism of the few who started to work in those days. Were there time, I might illustrate this by abundant examples; but I think a single illustration will suffice to demonstrate how progress during recent years has changed the outlook for biochemistry. I will ask you to note the language used thirty years ago to describe the chemical events in active muscle and compare it with that used now. In 1895 Michael Foster, a physiologist of deep vision, dealing with the respiration of tissues, and in particular with the degree to which the activity of muscle depends on its contemporary oxygen supply, expounded the current view which may be thus briefly summarized. The oxygen which enters the muscle from the blood is not involved in immediate oxidations, but is built up into the substance of the muscle. It disappears into some protoplasmic complex on which its presence confers instability. This complex, like all living substance, is to be regarded as incessantly undergoing changes of a double kind, those of building up and those of breaking down. With activity the latter predominates, and in the case of muscle the complex in question explodes, as it were, to yield the energy for contraction. "We can not yet trace," Foster comments, "the steps taken by the oxygen from the moment it slips from the blood into the muscle substance to the moment when it issues united with carbon as carbonic acid. The whole mystery of life lies hidden in that process, and for the present we must be content with simply knowing the beginning and the end." What we feel entitled to say to-day concerning the respiration of muscle and of the events associated with its activity requires, as I have suggested, a different language, and for those not interested in technical chemical aspects the very change of language may yet be significant. The conception of continuous building up and continuous breakdown of the muscle substance as a whole has but a small element of truth. The colloid muscle structure is, so to speak, an apparatus, relatively stable even as a whole when metabolism is normal, and in essential parts very stable. The chemical reactions which occur in that apparatus have been followed with a completeness which is, I think, striking. It is carbohydrate stores distinct from the apparatus (and in certain circumstances also fat stores) which undergo steady oxidation and are the ultimate sources of energy for muscular work. Es-

sential among successive stages in the chemical breakdown of carbohydrate which necessarily precede oxidation is the intermediate combination of a sugar (a hexose) with phosphoric acid to form an ester. This happening is indispensable for the progress of the next stage, namely, the production of lactic acid from the sugar, which is an anaerobic process. The precise happenings to the hexose sugar while in combination with phosphoric acid are from a chemical standpoint remarkable. Very briefly stated they are these! One half of the sugar molecule is converted into a molecule of glycerin and the other half into one of pyruvic acid. Now with loss of two hydrogen atoms glycerin yields lactic acid, and, with a gain of the same pyruvic acid also yields lactic acid. The actual happening then is that hydrogen is transferred from the glycerin molecule while still combined with phosphoric acid to the pyruvic acid molecule with the result that two molecules of lactic acid are formed.[2] The lactic acid is then, during a cycle of change which I must not stop to discuss, oxidized to yield the energy required by the muscle.

But the energy from this oxidation is by no means directly available for the mechanical act of contraction. The oxidation occurs indeed after and not before or during a contraction. The energy it liberates secures, however, the endothermic resynthesis of a substance, creatin phosphate, of which the breakdown at an earlier stage in the sequence of events is the more immediate source of energy for contraction. Even more complicated are these chemical relations, for it would seem that in the transference of energy from its source in the oxidation of carbohydrate to the system which synthesizes creatin phosphate, yet another reaction intervenes, namely, the alternating breakdown and resynthesis of the substance adenyl pyrophosphate. The sequence of these chemical reactions in muscle has been followed and their relation in time to the phases of contraction and relaxation is established. The means by which energy is transferred from one reacting system to another has still lately been obscure, but current work is throwing light upon this interesting question, and it is just beginning (though only beginning) to show how at the final stage the energy of the reactions is converted into the mechanical response. In parenthesis it may be noted as an illustration of the unity of life that the processes which occur in the living yeast cell in its dealings with sugars are closely similar to those which proceed in living muscle. In the earlier stages they are identical and we now know where they part company. You will, I think, be astonished at the complexity of the events which underlie the activity of a muscle, but you must remember that it is a highly specialized machine. A more direct burning of the fuel could not fit into its complex organization. I am more particularly concerned to feel that my brief summary of the facts will make you realize how much more definite, how much more truly chemical, is our present knowledge than that available when Michael Foster wrote. Ability to recognize the progress of such definite ordered chemical reactions in relation to various aspects of living activity characterizes the current position in biochemistry. I have chosen the case of muscle, and it must serve as my only example, but many such related and ordered reactions have been studied in other cells and tissues, from bacteria to the brain. Some prove general, some more special. Although we are far indeed from possessing a complete picture in any one case we are beginning in thought to fit not a few pieces together. We are on a line safe for progress.

I must perforce limit the field of my discussion, and in what follows my special theme will be the importance of molecular structure in determining the properties of living systems. I wish you to believe that molecules display in such systems the properties inherent in their structure even as they do in the laboratory of the organic chemist. The theme is no new one, but its development illustrates as well as any other, and to my own mind perhaps better than any other, the progress of biochemistry. Not long ago a prominent biologist, believing in protoplasm as an entity, wrote, "But it seems certain that living protoplasm is not an ordinary chemical compound, and therefore can have no molecular structure in the chemical sense of the word." Such a belief was common. One may remark, moreover, that when the development of colloid chemistry first brought its indispensable aid towards an understanding of the biochemical field, there was a tendency to discuss its bearing in terms of the less specific properties of colloid systems, phase-surfaces, membranes, and the like, without sufficient reference to the specificity which the influence of molecular structure, wherever displayed, impresses on chemical relations and events. In emphasizing its importance I shall leave no time for dealings with the nature of the colloid structures of cells and tissues, all important as they are. I shall continue to deal, though not again in detail, with chemical reactions as they occur within those structures. Only this much must be said. If the colloid structures did not display highly specialized molecular structure at their surface, no reactions would occur; for here catalysis occurs. Were it not equipped with catalysts, every living unit would be a static system.

With the phenomena of catalysis I will assume you have general acquaintance. You know that a catalyst is an agent which plays only a temporary part in chemical events which it nevertheless determines and controls. It reappears unaltered when the events are

[2] Lecture by Otto Meyerhof: in press (see *Nature*).

completed. The phenomena of catalysis, though first recognized early in the last century, entered but little into chemical thought or enterprise, till only a few years ago they were shown to have great importance for industry. Yet catalysis is one of the most significant devices of nature, since it has endowed living systems with their fundamental character as transformers of energy, and all evidence suggests that it must have played an indispensable part in the living universe from the earliest stages of evolution.

The catalysts of a living cell are the enzymic structures which display their influences at the surface of colloidal particles or at other surfaces within the cell. Current research continues to add to the great number of these enzymes which can be separated from, or recognized in, living cells and tissues, and to increase our knowledge of their individual functions.

A molecule within the system of the cell may remain in an inactive state and enter into no reactions until at one such surface it comes in contact with an enzymic structure which displays certain adjustments to its own structure. While in such association the inactive molecule becomes (to use a current term) "activated," and then enters on some definite path of change. The one aspect of enzymic catalysis which for the sake of my theme I wish to emphasize is its high specificity. An enzyme is in general adjusted to come into effective relations with one kind of molecule only, or at most with molecules closely related in their structure. Evidence based on kinetics justifies the belief that some sort of chemical combination between enzyme and related molecule precedes the activation of the latter, and for such combinations there must be close correlation in structure. Many will remember that long ago Emil Fischer recognized that enzymic action distinguishes even between two optical isomers and spoke of the necessary relation being as close as that of key and lock.

There is an important consequence of this high specificity in biological catalysis to which I will direct your special attention. A living cell is the seat of a multitude of reactions, and in order that it should retain in a given environment its individual identity as an organism, these reactions must be highly organized. They must be of determined nature and proceed mutually adjusted with respect to velocity, sequence, and in all other relations. They must be in dynamic equilibrium as a whole and must return to it after disturbance. Now if of any group of catalysts, such as are found in the equipment of a cell, each one exerts limited and highly specific influence, this very specificity must be a potent factor in making for organization.

Consider the case of any individual cell in due relations with its environment, whether an internal environment, as in the case of the tissue cells of higher animals, or an external environment, as in the case of unicellular organisms. Materials for maintenance of the cell enter it from the environment. Discrimination among such materials is primarily determined by permeability relations, but of deeper significance in that selection is the specificity of the cell catalysts. It has often been said that the living cell differs from all non-living systems in its power of selecting from a heterogeneous environment the right material for the maintenance of its structure and activities. It is, however, no vital act but the nature of its specific catalysts which determines what it effectively "selects." If a molecule gains entry into the cell and meets no catalytic influence capable of activating it, nothing further happens save for certain ionic and osmotic adjustments. Any molecule which does meet an adjusted enzyme can not fail to suffer change and become directed into some one of the paths of metabolism. It must here be remembered, moreover, that enzymes as specific catalysts not only promote reactions, but determine their direction. The glucose molecule, for example, though its inherent chemical potentialities are, of course, always the same, is converted into lactic acid by an enzyme system in muscle but into alcohol and carbon dioxide by another in the yeast cell. It is important to realize that diverse enzymes may act in succession and that specific catalysis has directive as well as selective powers. If it be syntheses in the cell which are most difficult to picture on such lines we may remember that biological syntheses can be, and are, promoted by enzymes, and there are sufficient facts to justify the belief that a chain of specific enzymes can direct a complex synthesis along lines, predetermined by the nature of the enzymes themselves. I should like to develop this aspect of the subject even further, but to do so might tax your patience. I should add that enzyme control, though so important, is not the sole determinant of chemical organization in a cell. Other aspects of its colloidal structure play their part.

III

It is surely at that level of organization, which is based on the exact coordination of a multitude of chemical events within it, that a living cell displays its peculiar sensitiveness to the influence of molecules of special nature when these enter it from without. The nature of very many organic molecules is such that they may enter a cell and exert no effect. Those proper to metabolism follow, of course, the normal paths of change. Some few, on the other hand, influence the cell in very special ways. When such influence is highly specific in kind it means that some element of structure in the entrant molecule is adjusted to meet an aspect of molecular structure somewhere in the cell itself. We can easily understand

that in a system so minute the intrusion even of a few such molecules may so modify existing equilibria as to affect profoundly the observed behavior of the cell.

Such relations, though by no means confined to them, reach their greatest significance in the higher organisms, in which individual tissues, chemically diverse, differentiated function and separated in space, so react upon one another through chemical agencies transmitted through the circulation as to coordinate by chemical transport the activities of the body as a whole. Unification by chemical means must to-day be recognized as a fundamental aspect of all such organisms. In all of them it is true that the nervous system has pride of place as the highest seat of organizing influence, but we know to-day that even this influence is often, if not always, exerted through properties inherent in chemical molecules. It is indeed most significant for my general theme to realize that when a nerve impulse reaches a tissue the sudden production of a definite chemical substance at the nerve ending may be essential to the response of that tissue to the impulse. It is a familiar circumstance that when an impulse passes to the heart by way of the vagus nerve fibers the beat is slowed, or, by a stronger beat, arrested. That is, of course, part of the normal control of the heart's action. Now it has been shown that whenever the heart receives vagus impulses the substance acetyl cholin is liberated within the organ. To this fact is added the further fact that in the absence of the vagus influence, the artificial injection of minute graded doses of acetyl choline so acts upon the heart as to reproduce in every detail the effects of graded stimulation of the nerve. Moreover, evidence is accumulating to show that in the case of other nerves belonging to the same morphological group as the vagus, but supplying other tissues, this same liberation of acetyl choline accompanies activity, and the chemical action of this substance upon such tissues again produces effects identical with those observed when the nerves are stimulated. More may be claimed. The functions of another group of nerves are opposed to those of the vagus group; impulses, for instance, through certain fibers accelerate the heart beat. Again a chemical substance is liberated at the endings of such nerves, and this substance has itself the property of accelerating the heart. We find then that such organs and tissues respond only indirectly to whatever non-specific physical change may reach the nerve ending. Their direct response is to the influence of particular molecules with an essential structure when these intrude into their chemical machinery.

It follows that the effect of a given nerve stimulus may not be confined to the tissue which it first reaches. There may be humeral transmissions of its effect, because the liberated substance enters the lymph and blood. This again may assist the coordination of events in the tissues.

From substances produced temporarily and locally and by virtue of their chemical properties translating for the tissues the messages of nerves, we may pass logically to consideration of those active substances which carry chemical messages from organ to organ. Such in the animal body are produced continuously in specialized organs, and each has its special seat or seats of action where it finds chemical structures adjusted in some sense or other to its own.

I shall be here on familiar ground, for that such agencies exist, and bear the name of hormones is common knowledge. I propose only to indicate how many and diverse are their functions, as revealed by recent research, emphasizing the fact that each one is a definite and relatively simple substance with properties that are primarily chemical and in a derivative sense physiological. Our clear recognition of this, based at first on a couple of instances, began with this century, but our knowledge of their number and nature is still growing rapidly to-day.

We have long known, of course, how essential and profound is the influence of the thyroid gland in maintaining harmonious growth in the body, and in controlling the rate of its metabolism. Three years ago a brilliant investigation revealed the exact molecular structure of the substance—thyroxin—which is directly responsible for these effects. It is a substance of no great complexity. The constitution of adrenalin has been longer known and likewise its remarkable influence in maintaining a number of important physiological adjustments. Yet it is again a relatively simple substance. I will merely remind you of secretin, the first of these substances to receive the name of hormone, and of insulin, now so familiar because of its importance in the metabolism of carbohydrates and its consequent value in the treatment of diabetes. The most recent growth of knowledge in this field has dealt with hormones which, in most remarkable relations, coordinate the phenomena of sex.

It is the circulation of definite chemical substances produced locally that determines during the growth of the individual the proper development of all the secondary sexual characters. The properties of other substances secure the due progress of individual development from the unfertilized ovum to the end of fetal life. When an ovum ripens and is discharged from the ovary a substance, now known as estrin, is produced in the ovary itself, and so functions as to bring about all those changes in the female body which make secure the fertilization of the ovum. On the discharge of the ovum new tissue, constituting the so-called *corpus luteum,* arises in its place. This

then produces a special hormone which in its turn evokes all those changes in tissues and organs that secure a right destiny for the ovum after it has been fertilized. It is clear that these two hormones do not arise simultaneously, for they must act in alternation, and it becomes of great interest to know how such succession is secured. The facts here are among the most striking. Just as higher nerve centers in the brain control and coordinate the activities of lower centers, so it would seem do hormones, functioning at, so to speak, a higher level in organization, coordinate the activities of other hormones. It is a substance produced in the anterior portion of the pituitary gland situated at the base of the brain, which by circulating to the ovary controls the succession of its hormonal activities. The cases I have mentioned are far from exhausting the numerous hormonal influences now recognized.

For full appreciation of the extent to which chemical substances control and coordinate events in the animal body by virtue of their specific molecular structure, it is well not to separate too widely in thought the functions of hormones from those of vitamins. Together they form a large group of substances of which every one exerts upon physiological events its own indispensable chemical influence.

Hormones are produced in the body itself, while vitamins must be supplied in the diet. Such a distinction is, in general, justified. We meet occasionally, however, an animal species able to dispense with an external supply of this or that vitamin. Evidence shows, however, that individuals of that species, unlike most animals, can in the course of their metabolism synthesize for themselves the vitamin in question. The vitamin then becomes a hormone. In practise the distinction may be of great importance, but for an understanding of metabolism the functions of these substances are of more significance than their origin.

The present activity of research in the field of vitamins is prodigious. The output of published papers dealing with original investigations in the field has reached nearly a thousand in a single year. Each of the vitamins at present known is receiving the attention of numerous observers in respect both of its chemical and biological properties, and though many publications deal, of course, with matters of detail, the accumulation of significant facts is growing fast.

It is clear that I can cover but little ground in any reference to this wide field of knowledge. Some aspects of its development have been interesting enough. The familiar circumstance that attention was drawn to the existence of one vitamin (B_1 so called) because populations in the East took to eating milled rice instead of the whole grain; the gradual growth of evidence which links the physiological activities of another vitamin (D) with the influence of solar radiation on the body, and has shown that they are thus related, because rays of definite wave-length convert an inactive precursor into the active vitamin, alike when acting on foodstuffs or on the surface of the living body; the fact again that the recent isolation of vitamin C and the accumulation of evidence for its nature started from the observation that the cortex of the adrenal gland displayed strongly reducing properties; or yet again the proof that a yellow pigment widely distributed among plants, while not the vitamin itself, can be converted within the body into vitamin A; these and other aspects of vitamin studies will stand out as interesting chapters in the story of scientific investigation.

In this very brief discussion of hormones and vitamins I have so far referred only to their functions as manifested in the animal body. Kindred substances, exerting analogous functions, are, however, of wide and perhaps of quite general biological importance. It is certain that many microorganisms require a supply of vitamin-like substances for the promotion of growth, and recent research of a very interesting kind has demonstrated in the higher plants the existence of specific substances produced in special cells which stimulate growth in other cells, and so in the plant as a whole. These so-called auxines are essentially hormones. Section B will soon be listening to an account of their chemical nature.

It is of particular importance to my present theme and a source of much satisfaction to know that our knowledge of the actual molecular structure of hormones and vitamins is growing fast. We have already exact knowledge of the kind in respect to not a few. We are indeed justified in believing that within a few years such knowledge will be extensive enough to allow a wide view of the correlation between molecular structure and physiological activity. Such correlation has long been sought in the case of drugs, and some generalizations have been demonstrated. It should be remembered, however, that until quite lately only the structure of the drug could be considered. With increasing knowledge of the tissue structures pharmacological actions will become much clearer.

I can not refrain from mentioning here a set of relations connected especially with the phenomena of tissue growth which are of particular interest. It will be convenient to introduce some technical chemical considerations in describing them, though I think the relations may be clear without emphasis being placed on such details. The vitamin which in current usage is labeled "A" is essential for the general growth of an animal. Recent research has provided much information as to its chemical nature. Its molecule is

built up of units which possess what is known to chemists as the isoprene structure. These are condensed in a long carbon chain which is attached to a ring structure of a specific kind. Such a constitution relates it to other biological compounds, in particular to certain vegetable pigments, one of which a carotene, so called, is the substance which I have mentioned as being convertible into the vitamin. For the display of an influence upon growth, however, the exact details of the vitamin's proper structure must be established. Now turning to vitamin D, of which the activity is more specialized, controlling as it does the growth of bone in particular, we have learned that the unit elements in its structure are again isoprene radicals; but instead of forming a long chain as in vitamin A they are united into a system of condensed rings. Similar rings form the basal component of the molecules of sterols, substances which are normal constituents of nearly every living cell. It is one of these, inactive itself, which ultra-violet radiation converts into vitamin D. We know that as stated each of these vitamins stimulates growth in tissue cells. Next consider another case of growth stimulation, different because pathological in nature. As you are doubtless aware, it is well known that long contact with tar induces a cancerous growth of the skin. Very important researches have recently shown that particular constituents in the tar are alone concerned in producing this effect. It is being further demonstrated that the power to produce cancer is associated with a special type of molecular structure in these constituents. This structure, like that of the sterols, is one of condensed rings, the essential difference being that (in chemical language) the sterol rings are hydrogenated, whereas those in the cancer-producing molecules are not. Hydrogenation indeed destroys the activity of the latter. Recall, however, the ovarian hormone estrin. Now the molecular structure of estrin has the essential ring structure of a sterol, but one of the constituent rings is not hydrogenated. In a sense therefore the chemical nature of estrin links vitamin D with that of cancer-producing substances. Further, it is found that substances with pronounced cancer-producing powers may produce effects in the body like those of estrin. It is difficult when faced with such relations not to wonder whether the metabolism of sterols, which when normal can produce a substance stimulating physiological growth, may in very special circumstances be so perverted as to produce within living cells a substance stimulating pathological growth. Such a suggestion must, however, with present knowledge, be very cautiously received. It is wholly without experimental proof. My chief purpose in this reference to this very interesting set of relations is to emphasize once more the significance of chemical structure in the field of biological events.

Only the end results of the profound influence which minute amounts of substances with adjusted structure exert upon living cells or tissues can be observed in the intact bodies of man or animals. It is doubtless because of the elaborate and sensitive organization of chemical events in every tissue cell that the effects are proportionally so great.

It is an immediate task of biochemistry to explore the mechanism of such activities. It must learn to describe in objective chemical terms precisely how and where such molecules as those of hormones and vitamins intrude into the chemical events of metabolism. It is indeed now beginning this task, which is by no means outside the scope of its methods. Efforts of this and of similar kind can not fail to be associated with a steady increase in knowledge of the whole field of chemical organization in living organisms, and to this increase we look forward with confidence. The promise is there. Present methods can still go far, but I am convinced that progress of the kind is about to gain great impetus from the application of those new methods of research which chemistry is inheriting from physics: X-ray analysis; the current studies of unimolecular surface films and of chemical reactions at surfaces; modern spectroscopy; the quantitative developments of photochemistry; no branch of inquiry stands to gain more from such advances in technique than does biochemistry at its present stage. Especially is this true in the case of the colloidal structure of living systems, of which in this address I have said so little.

IV

As an experimental science, biochemistry, like classical physiology, and much of experimental biology, has obtained, and must continue to obtain, many of its data from studying parts of the organism in isolation, but parts in which dynamic events continue. Though fortunately it has also methods of studying reactions as they occur in intact living cells, intact tissues and, of course, in the intact animal, it is still entitled to claim that its studies of parts are consistently developing its grasp of the wholes it desires to describe, however remote that grasp may be from finality. Justification for any such claim has been challenged in advance from a certain philosophic standpoint. Not from that of General Smuts, though in his powerful address which signalized our centenary meeting he, like many philosophers to-day, emphasized the importance of properties which emerge from systems in their integrity, bidding us remember that a part while in the whole is not the same as the part in isolation. He hastened to admit in a subsequent speech, however, that for experimental biology, as for any other branch of science, it was logical and necessary to approach the whole through its parts.

Nor again is the claim challenged from the standpoint of such a teacher as A. N. Whitehead, though in his philosophy of organic mechanism there is no real entity of any kind without internal and multiple relations, and each whole is more than the sum of its parts. I nevertheless find *ad hoc* statements in his writings which directly encourage the methods of biochemistry. In the teachings of J. S. Haldane, however, the value of such methods have long been directly challenged. Some here will perhaps remember that in his address to Section I, twenty-five years ago he described a philosophic standpoint which he has courageously maintained in many writings since. Dr. Haldane holds that to the enlightened biologist a living organism does not present a problem for analysis; it is, *qua* organism, axiomatic. Its essential attributes are axiomatic; heredity, for example, is for biology not a problem but an axiom. "The problem of physiology is not to obtain piecemeal physico-explanations of physiological processes" (I quote from the 1885 address), "but to discover by observation and experiment the relatedness to one another of all the details of structure and activity in each organism as expressions of its nature as one organism." I can not pretend adequately to discuss these views here. They have often been discussed by others, not always perhaps with understanding. What is true in them is subtle, and I doubt if their author has ever found the right words in which to bring to most others a conviction of such truth. It is involved in a world outlook. What I think is scientifically faulty in Haldane's teaching is the *a priori* element which leads to bias in the face of evidence. The task he sets for the physiologist seems vague to most people, and he forgets that with good judgment a study of parts may lead to an intellectual synthesis of value. In 1885 he wrote: "That a meeting-point between biology and physical science may at some time be found there is no reason for doubting. But we may confidently predict that if that meeting-point is found, and one of the two sciences is swallowed up, that one will not be biology." He now claims indeed that biology has accomplished the heavy meal, because physics has been compelled to deal no longer with Newtonian entities but, like the biologist, with organisms such as the atom proves to be. Is it not then enough for my present purpose to remark on the significance of the fact that not until certain atoms were found spontaneously splitting piecemeal into parts, and others were afterwards so split in the laboratory, did we really know anything about the atom as a whole.

At this point, however, I will ask you not to suspect me of claiming that all the attributes of living systems or even the more obvious among them are necessarily based upon chemical organization alone. I have already expressed my own belief that this organization will account for one striking characteristic of every living cell—its ability, namely, to maintain a dynamic individuality in diverse environments. Living cells display other attributes even more characteristic of themselves; they grow, multiply, inherit qualities and transmit them. Although to distinguish levels of organization in such systems may be to abstract from reality it is not illogical to believe that such attributes as these are based upon organization at a level which is in some sense higher than the chemical level. The main necessity from the standpoint of biochemistry is then to decide whether nevertheless at its own level, which is certainly definable, the results of experimental studies are self-contained and consistent. This is assuredly true of the data which biochemistry is now acquiring. Never during its progress has chemical consistency shown itself to be disturbed by influences of any ultrachemical kind.

Moreover, before we assume that there is a level of organization at which chemical controlling agencies must necessarily cease to function, we should respect the intellectual parsimony taught by Occam and be sure of their limitations before we seek for superchemical entities as organizers. There is no orderly succession of events which would seem less likely to be controlled by the mere chemical properties of a substance than the cell divisions and cell differentiation which intervene between the fertilized ovum and the finished embryo. Yet it would seem that a transmitted substance, a hormone in essence, may play an unmistakable part in that remarkable drama. It has for some years been known that, at an early stage of development, a group of cells forming the so-called "organizer" of Spemann induces the subsequent stages of differentiation in other cells. The latest researches seem to show that a cell-free extract of this "organizer" may function in its place. The substance concerned is, it would seem, not confined to the "organizer" itself, but is widely distributed outside, though not in, the embryo. It presents, nevertheless, a truly remarkable instance of chemical influence.

It would be out of place in such a discourse as this to attempt any discussion of the psycho-physical problem. However much we may learn about the material systems which, in their integrity, are associated with consciousness, the nature of that association may yet remain a problem. The interest of that problem is insistent and it must be often in our thoughts. Its existence, however, justifies no prejudgments as to the value of any knowledge of a consistent sort which the material systems may yield to experiment.

V

It has become clear, I think, that chemical modes of thought, whatever their limitation, are fated profoundly to affect biological thought. If, however, the biochemist should at any time be inclined to overrate the value of his contributions to biology or to underrate the magnitude of problems outside his province, he will do well sometimes to leave the laboratory for the field, or to seek even in the museum a reminder of that infinity of adaptations of which life is capable. He will then not fail to work with a humble mind, however great his faith in the importance of the methods which are his own.

It is surely right, however, to claim that in passing from its earlier concern with dead biological products to its present concern with active processes within living organisms, biochemistry has become a true branch of progressive biology. It has opened up modes of thought about the physical basis of life which could scarcely be employed at all a generation ago. Such data and such modes of thought as it is now providing are pervasive, and must appear as aspects in all biological thought. Yet these aspects are, of course, only partial. Biology in all its aspects is showing rapid progress, and its bearing on human welfare is more and more evident.

Unfortunately, the nature of this new biological progress and its true significance is known to but a small section of the lay public. Few will doubt that popular interest in science is extending, but it is mainly confined to the more romantic aspects of modern astronomy and physics. That biological advances have made less impression is probably due to more than one circumstance, of which the chief, doubtless, is the neglect of biology in our educational system. The startling data of modern astronomy and physics, though of course only when presented in their most superficial aspects, find an easier approach to the uninformed mind than those of the new experimental biology can hope for. The primary concepts involved are paradoxically less familiar. Modern physical science, moreover, has been interpreted to the intelligent public by writers so brilliant that their books have had a great and stimulating influence.

Lord Russell once ventured on the statement that in passing from physics to biology one is conscious of a transition from the cosmic to the parochial, because from a cosmic point of view life is a very unimportant affair. Those who know that supposed parish well are convinced that it is rather a metropolis entitled to much more attention than it sometimes obtains from authors of guide-books to the universe. It may be small in extent, but is the seat of all the most significant events. In too many current publications, purporting to summarize scientific progress, biology is left out or receives but scant reference. Brilliant expositions of all that may be met in the region where modern science touches philosophy have directed thought straight from the implications of modern physics to the nature and structure of the human mind, and even to speculation concerning the mind of the Deity. Yet there are aspects of biological truth already known which are certainly germane to such discussions, and probably necessary for their adequacy.

VI

It is, however, because of its extreme importance to social progress that public ignorance of biology is especially to be regretted. Sir Henry Dale has remarked that "it is worth while to consider to-day whether the imposing achievements of physical science have not already, in the thought and interests of men at large, as well as in technical and industrial development, overshadowed in our educational and public policy those of biology to an extent which threatens a one-sided development of science itself and of the civilization which we hope to see based on science." Sir Walter Fletcher, whose death during the past year has deprived the nation of an enlightened adviser, almost startled the public, I think, when he said in a national broadcast that "we can find safety and progress only in proportion as we bring into our methods of statecraft the guidance of biological truth." That statecraft, in its dignity, should be concerned with biological teaching, was a new idea to many listeners. A few years ago the Cambridge philosopher, Dr. C. D. Broad, who is much better acquainted with scientific data than are many philosophers, remarked upon the misfortune involved in the unequal development of science; the high degree of our control over inorganic nature combined with relative ignorance of biology and psychology. At the close of a discussion as to the possibility of continued mental progress in the world, he summed up by saying that the possibility depends on our getting an adequate knowledge and control of life and mind before the combination of ignorance on these subjects with knowledge of physics and chemistry wrecks the whole social system. He closed with the somewhat startling words: "Which of the runners in this very interesting race will win it is impossible to foretell. But physics and death have a long start over psychology and life!" No one surely will wish for, or expect, a slowing in the pace of the first, but the quickening up in the latter which the last few decades have seen is a matter for high satisfaction. But, to repeat, the need for recognizing biological truth as a necessary guide to individual conduct and no less to statecraft and social policy still needs emphasis to-day. With frank acceptance of the truth that his own nature is congruent

with all those aspects of nature at large which biology studies, combined with intelligent understanding of its teaching, man would escape from innumerable inhibitions, due to past history and present ignorance, and equip himself for higher levels of endeavor and success.

Inadequate as at first sight it may seem when standing alone in support of so large a thesis, I must here be content to refer briefly to a single example of biological studies bearing upon human welfare. I will choose one which stands near to the general theme of my address. I mean the current studies of human and animal nutrition. You are well aware that during the last twenty years—that is, since it adopted the method of controlled experiment—the study of nutrition has shown that the needs of the body are much more complex than was earlier thought, and in particular that substances consumed in almost infinitesimal amounts may, each in its way, be as essential as those which form the bulk of any adequate dietary. This complexity in its demands will, after all, not surprise those who have in mind the complexity of events in the diverse living tissues of the body.

My earlier reference to vitamins, which had somewhat different bearings, was, I am sure, not necessary for a reminder of their nutritional importance. Owing to abundance of all kinds of advertisement vitamins are discussed in the drawing-room as well as in the dining-room, and also, though not so much, in the nursery, while at present perhaps not enough in the kitchen. Unfortunately, among the uninformed their importance in nutrition is not always viewed with discrimination. Some seem to think nowadays that if the vitamin supply is secured the rest of the dietary may be left to chance, while others suppose that they are things so good that we can not have too much of them. Needless to say, neither assumption is true. With regard to the second indeed it is desirable, now that vitamin concentrates are on the market and much advertised, to remember that excess of a vitamin may be harmful. In the case of that labeled D at least we have definite evidence of this. Nevertheless, the claim that every known vitamin has highly important nutritional functions is supported by evidence which continues to grow. It is probable, but perhaps not yet certain, that the human body requires all that are known.

The importance of detail is no less in evidence when the demands of the body for a right mineral supply are considered. A proper balance among the salts which are consumed in quantity is here of prime importance, but that certain elements which ordinary foods contain in minute amounts are indispensable in such amounts is becoming sure. To take but a single instance: The necessity of a trace of copper, which exercises somewhere in the body an indispensable catalytic influence on metabolism, is as essential in its way as much larger supplies of calcium, magnesium, potassium or iron. Those in close touch with experimental studies continually receive hints that factors still unknown contribute to normal nutrition, and those who deal with human dietaries from a scientific standpoint know that an ideal diet can not yet be defined. This reference to nutritional studies is indeed mainly meant to assure you that the great attention they are receiving is fully justified. No one here, I think, will be impressed with the argument that because the human race has survived till now in complete ignorance of all such details the knowledge being won must have academic interest alone. This line of argument is very old and never right.

One thing I am sure may be claimed for the growing enlightenment concerning human nutrition and the recent recognition of its study. It has already produced one line of evidence to show that nurture can assist nature to an extent not freely admitted a few years ago. That is a subject which I wish I could pursue. I can not myself doubt that various lines of evidence, all of which should be profoundly welcome, are pointing in the same direction.

Allow me just one final reference to another field of nutritional studies. Their great economic importance in animal husbandry calls for full recognition. Just now agricultural authorities are becoming acutely aware of the call for a better control of the diseases of animals. Together these involve an immense economic loss to the farmers, and therefore to the country. Although, doubtless, its influence should not be exaggerated, faulty nutrition plays no small share in accounting for the incidence of some among these diseases, as researches carried out at the Rowett Institute in Aberdeen and elsewhere are demonstrating. There is much more of such work to be done with great profit.

VII

In every branch of science the activity of research has greatly increased during recent years. This all will have realized, but only those who are able to survey the situation closely can estimate the extent of that increase. It occurred to me at one time that an appraisement of research activities in this country, and especially the organization of state-aided research, might fittingly form a part of my address. The desire to illustrate the progress of my own subject led me away from that project. I gave some time to a survey, however, and came to the conclusion, among others, that from eight to ten individuals in the world are now engaged upon scientific investigations for every one so engaged twenty years ago. It must be

remembered, of course, that not only has research endowment greatly increased in America and Europe, but that Japan, China and even India have entered the field and are making contributions to science of real importance. It is sure that, whatever the consequences, the increase of scientific knowledge is at this time undergoing a positive acceleration.

Apropos, I find difficulty as to-day's occupant of this important scientific pulpit in avoiding some reference to impressive words spoken by my predecessor which are still echoed in thought, talk and print. In his wise and eloquent address at York Sir Alfred Ewing reminded us with serious emphasis that the command of nature has been put into man's hand before he knows how to command himself. Of the dangers involved in that indictment he warned us; and we should remember that General Smuts also sounded the same note of warning in London.

Of science itself it is, of course, no indictment. It may be thought of rather as a warning signal to be placed on her road: "Dangerous Hill Ahead," perhaps, or "Turn Right"; not, however, "Go Slow," for that advice science can not follow. The indictment is of mankind. Recognition of the truth it contains can not be absent from the minds of those whose labors are daily increasing mankind's command of nature; but it is due to them that the truth should be viewed in proper perspective. It is, after all, war, to which science has added terrors, and the fear of war, which alone give it real urgency—an urgency which must of course be felt in these days when some nations at least are showing the spirit of selfish and dangerous nationalism. I may be wrong, but it seems to me that, war apart, the gifts of science and invention have done little to increase opportunities for the display of the more serious of man's irrational impulses. The worst they do perhaps is to give to clever and predatory souls that keep within the law the whole world for their depredations, instead of a parish or a country as of yore.

But Sir Alfred Ewing told us of "the disillusion with which, now standing aside, he watches the sweeping pageant of discovery and invention in which he used to make unbounded delight." I wish that one to whom applied science and this country owe so much might have been spared such disillusion, for I suspect it gives him pain. I wonder whether, if he could have added to an "Engineer's Outlook" the outlook of a biologist, the disillusion would still be there. As one just now advocating the claims of biology I would much like to know. It is sure, however, that the gifts of the engineer to humanity at large are immense enough to outweigh the assistance he may have given to the forces of destruction.

It may be claimed for biological science, in spite of vague references to bacterial warfare and the like, that it is not of its nature to aid destruction. What it may do towards making man as a whole more worthy of his inheritance has yet to be fully recognized. On this point I have said much. Of its service to his physical betterment you will have no doubts. I have made but the bare reference in this address to the support that biological research gives to the art of medicine. I had thought to say much more of this, but found that if I said enough I could say nothing else.

There are two other great questions so much to the front just now that they tempt a final reference. I mean, of course, the paradox of poverty amidst plenty and the replacement of human labor by machinery. Applied science should take no blame for the former, but indeed claim credit unfairly lost. It is not within my capacity to say anything of value about the paradox and its cure; but I confess that I see more present danger in the case of "Money *versus* Man" than danger present or future in that of the "Machine *versus* Man"!

With regard to the latter it is surely right that those in touch with science should insist that the replacement of human labor will continue. Those who doubt this can not realize the meaning of that positive acceleration in science, pure and applied, which now continues. No one can say what kind of equilibrium the distribution of leisure is fated to reach. In any case an optimistic view as to the probable effects of its increase may be justified.

It need not involve a revolutionary change if there is real planning for the future. Lord Melchett was surely right when some time ago he urged on the upper House that present thought should be given to that future; but I think few men of affairs seriously believe what is yet probable, that the replacement we are thinking of will impose a new structure upon society. This may well differ in some essentials from any of those alternative social forms of which the very names now raise antagonisms. I confess that if civilization escapes its other perils I should fear little the final reign of the machine. We should not altogether forget the difference in use which can be made of real and ample leisure compared with that possible for very brief leisure associated with fatigue; nor the difference between compulsory toil and spontaneous work. We have to picture, moreover, the reactions of a community which, save for a minority, has shown itself during recent years to be educable. I do not think it fanciful to believe that our highly efficient national broadcasting service, with the increased opportunities which the coming of short wavelength transmission may provide, might well take charge of the systematic education of adolescents after

the personal influence of the schoolmaster has prepared them to profit by it. It would not be a technical education but an education for leisure. Listening to organized courses of instruction might at first be for the few; but ultimately might become habitual in the community which it would specially benefit.

In parenthesis allow me a brief further reference to "planning." The word is much to the front just now, chiefly in relation with current enterprises. But there may be planning for more fundamental developments; for future adjustment to social reconstructions. In such planning the trained scientific mind must play its part. Its vision of the future may be very limited, but in respect of material progress and its probable consequences science (I include all branches of knowledge to which the name applies) has at least better data for prophecy than other forms of knowledge.

It was long ago written, "Wisdom and knowledge shall be stability of Thy times." Though statesmen may have wisdom adequate for the immediate and urgent problems with which it is their fate to deal, there should yet be a reservoir of synthesized and clarified knowledge on which they can draw. The technique which brings governments in contact with scientific knowledge in particular, though greatly improved of late, is still imperfect. In any case the politician is perforce concerned with the present rather than the future. I have recently read Bacon's "New Atlantis" afresh and have been thinking about his Solomon's House. We know that the rules for the functioning of that House were mistaken because the philosopher drew them up when in the mood of a Lord Chancellor; but in so far as the philosopher visualized therein an organization of the best intellects bent on gathering knowledge for future practical services, his idea was a great one. When civilization is in danger and society in transition might there not be a House recruited from the best intellects in the country with functions similar (*mutatis mutandis*) to those of Bacon's fancy? A House devoid of politics, concerned rather with synthesizing existing knowledge, with a sustained appraisement of the progress of knowledge, and continuous concern with its bearing upon social readjustments. It is not to be pictured as composed of scientific authorities alone. It would be rather an intellectual exchange where thought would go ahead of immediate problems. I believe, perhaps foolishly, that given time I might convince you that the functions of such a House, in such days as ours, might well be real. Here I must leave them to your fancy, well aware that in the minds of many I may by this bare suggestion lose all reputation as a realist!

I will now hasten to my final words. Most of us have had a tendency in the past to fear the gift of leisure to the majority. To believe that it may be a great social benefit requires some mental adjustment, and a belief in the educability of the average man or woman.

But if the political aspirations of the nations should grow sane, and the artificial economic problems of the world be solved, the combined and assured gifts of health, plenty and leisure may prove to be the final justification of applied science. In a community advantaged by these each individual will be free to develop his own innate powers, and, becoming more of an individual, will be less moved by those herd instincts which are always the major danger to the world.

You may feel that throughout this address I have dwelt exclusively on the material benefits of science to the neglect of its cultural value. I would like to correct this in a single closing sentence. I believe that for those who cultivate it in a right and humble spirit, science is one of the humanities—no less.

SCIENTIFIC EVENTS

SURVEY OF THE SHRIMP INDUSTRY BY THE BUREAU OF FISHERIES

PLANS have been completed by the Bureau of Fisheries to conduct an economic survey of the shrimp fishery of the southern states to dovetail with the biological survey which has been in progress for several months.

Frank T. Bell, commissioner of fisheries, in announcing the survey, pointed out that the shrimp fishery in 1929 ranked fifth in order of value to fishermen and ninth in volume among all fisheries of the United States. In that year, the shrimp fishery produced 113,000,000 pounds valued at $4,575,000 to the fishermen. Since then the value and volume have decreased slightly.

The purpose of the economic survey, which will be made by F. F. Johnson, of the bureau, is to supply shrimp fishermen with information on production and marketing conditions, as well as general information intended to facilitate the more orderly pursuit of the fishery.

The biological study has produced more tangible results in the past year than all previous studies of this type. Among other things, it has been determined that the life span of the shrimp is but one year. This fact establishes the necessity of "timing" the harvest so that the shrimp may be taken at a time when they have attained the best size from a market standpoint, and that allowances also may be made for spawning.

The subject of spawning, however, is one on which very little scientific information exists. In the first place, a fertilized egg of *Penaeus setiferus,* the commercial species of shrimp, has never been found, according to Dr. F. W. Weymouth, who is in charge of the biological study for the bureau. His assistant, M. J. Lindner, however, has estimated that a single shrimp may deposit or lay as many as 800,000 eggs at the single spawning during the animal's life span.

Commissioner Bell said it is expected that the combined economic and biological survey will furnish information upon which may be based conservation programs in the future, and efficient marketing in the immediate future. The bureau is said to look upon this program as one which will serve as insurance for the industry which is of first importance to Louisiana, Florida, Texas, Mississippi, Georgia and North and South Carolina.

The importance in which these states hold the shrimp fishery may be judged by the fact that Louisiana, Florida, Georgia and Texas are actively cooperating with the bureau in its biological survey.

PINNACLES NATIONAL MONUMENT

PINNACLES NATIONAL MONUMENT, California, a reservation administered by the National Park Service, has been enlarged through considerable extension of its northeastern, northwestern and southern boundaries. A proclamation legalizing the addition was signed recently by President Roosevelt. The addition comprises 5,001.78 acres, making the total area of the monument now 9,908.39 acres, more than double its former size.

Most of the grounds of the monument still lie within the County of San Benito, California, but a part of the new Chalone Mountain area lies within Monterey County.

The monument has been added to several times since first being set aside on January 16, 1908. The vast new addition will greatly facilitate administration. Besides providing additional parking space and affording better protection, it serves generally to round out the boundary to desirable proportions. The southern part of the addition, by far the most considerable, embraces beautiful Chalone Mountain. Besides its scenic attraction, this is an important breeding and grazing ground for deer.

Spires, domes, caves and subterranean passages of extraordinary grandeur distinguish this monument. Spirelike rock formations, the result of prehistoric volcanic action, provide reason for the appropriate naming of the reservation. The pinnacles rise from 600 to 1,000 feet above the canyon floors, a prominent landmark visible for many miles around. Some of the rocks are so precipitous as to be unscalable. A cave network of unusual natural attraction lies under each of the groups of rocks.

Pinnacles National Monument bears yet another feature, aside from its geological and scenic interest. It is important as one of the last strongholds and breeding places of the California condor, the largest bird in the state. Other bird life also is abundant here, due to the protection given.

THE YALE EXPEDITION TO NEWFOUNDLAND

THE Yale Geological Expedition to western Newfoundland has returned to Peabody Museum with an extensive collection of fossils, photographs and new geologic data. The expedition, under the leadership of Professor Carl O. Dunbar, of Yale, was greatly facilitated by the use of the steam yacht *Utowana,* owned by Mr. Allison V. Armour, Yale, '84, of New York City, who is a member of the advisory council of Peabody Museum. The *Utowana* has carried a number of exploring expeditions for the United States Department of Agriculture, and for Harvard and Princeton Universities. She has a length of 236 feet and is especially equipped for scientific work, with laboratory facilities and a photographic dark room.

The personnel of the expedition, in addition to Professor Dunbar, included F. Earl Ingerson, of Barstow, Texas, and Edward I. Leith, of Prince George, British Columbia, both students of geology in the Yale Graduate School; Percy A. Morris, preparator in the Peabody Museum, and Carl Owen Dunbar, Jr., a student in Hopkins Grammar School. The party left New Haven late in June, with the purpose of studying the older Paleozoic rocks along the west coast of Newfoundland, a region that Professor Dunbar has visited twice previously. During July their work was centered about Port au Port, Humber Arm of the Bay of Islands, and Cow Head Peninsula, in the southern and central portions of the west coast. During August the *Utowana* took the expedition north to Labrador for a few days' collecting, and then put the members ashore at various points in northwestern Newfoundland that would otherwise be difficult of access. In addition to this service, the yacht enabled the expedition to bring back to Peabody Museum extensive collections of fossils. Professor C. F. W. McClure, of Princeton University, and Mrs. McClure, accompanied Mr. Armour on the cruise.

The island of Newfoundland is in general a plateau of rolling relief, sloping southeastward from the Long Range Mountains, which parallel its western margin and rise to elevations of some 2,000 feet. The west side of these mountains shows a wall-like face, due to faulting, which is cut by but few streams. Between it and the sea lies a low coastal belt of about ten miles

width, made up of sedimentary rocks of early Paleozoic age; these rocks and their relations to the mountains behind them formed the major study of the expedition.

The rocks in places are rich in the fossilized remains of small sea animals which serve to date the strata, and the collecting of these fossils engaged the special attention of Messrs. Dunbar, Leith and Morris, while Mr. Ingerson studied the great masses of igneous rocks that were thrust up through the older rocks at Bonne Bay and around the Bay of Islands as a result of disturbances deep within the earth's crust. At Cow Head the party studied the extraordinary Cow Head conglomerates, with blocks of all sizes up to 600 feet in length, the largest of the kind known anywhere. From Labrador they brought back to Peabody Museum specimens of the reefs made by the "Archaeocyathinae."

THE LANGMUIR AWARD OF THE AMERICAN CHEMICAL SOCIETY

Dr. Frank Harold Spedding, instructor in chemistry at the University of California, was presented with the Langmuir Medal of the American Chemical Society for his research on the structure of the atom, at the eighty-sixth meeting of the society, held in Chicago from September 10 to 15. Dr. Spedding addressed the Division of Physical and Inorganic Chemistry on "Energy Levels in Solids."

The prize was established by Dr. A. C. Langmuir, brother of Dr. Irving Langmuir. It provides for "recognition of the accomplishment in North America of outstanding research in pure chemistry by a young man or woman, preferably working in a college or university." To be eligible for the award, "a candidate shall not have passed his thirty-first birthday." "Outstanding research" is construed to mean work of unusual merit for an individual standing on the threshold of his career. Dr. Charles L. Reese, president-elect of the American Chemical Society, was chairman of the committee on the Langmuir Award. Other members were Professor Arthur E. Hill, New York University; Professor Hobart H. Willard, University of Michigan; President James Bryant Conant, Harvard University; Professor Harold C. Urey, Columbia University; Professor Homer B. Adkins, University of Wisconsin, and Dr. John Johnston, director of research for the United States Steel Corporation.

The committee has issued the following account of the work for which the award has been made:

> Beginning his research in collaboration with Dr. Simon Freed and continuing alone, and with other collaborators, Dr. Spedding has, by extensive experimental and theoretical investigation, opened a wide new field of spectroscopy, which is of the utmost importance in the understanding of the chemical and magnetic properties of the rare earths.
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> In this extremely difficult study of the many lines in the absorption spectrum of crystals at temperatures ranging from room temperature to the temperature of boiling hydrogen, the first important result was that obtained with samarium. It had already been supposed, from the magnetic behavior of samarium, that it exists in more than one state, the relative amounts varying with the temperature.
>
> This was confirmed, and from a study of the intensities of the absorption lines at different temperatures, it was possible to calculate the relative amounts in the different states and their difference in energy.
>
> The next important subject dealt with in these researches was the study of intermolecular electric fields, concerning which much information has been obtained by studying the shift in the spectral lines caused by the substitution of one salt of gadolinium for another. This information was further advanced by a study of crystals with different types of symmetry.
>
> It was next attempted to study the absorption spectrum of crystals of the rare earths salts in a magnetic field, and it was found possible to obtain what is known as a Zeeman effect, and a Paschenback effect, which has been of the greatest service in classifying the spectral lines, and interpreting the exact spectroscopic definitions of the normal and excited states of the elements of the rare earths.
>
> A study of aqueous solutions of salts of the earths was then carried on, in which evidence was obtained of the orientation in the coordination zone of hydrated ions in solution. The study of the spectrum of light reflected from powdered crystals was then undertaken and led to several curious and at first mysterious phenomena, which have since been fully explained.
>
> The result of all these investigations carried on by Dr. Spedding and his collaborators is that the interpretation of the spectroscopic terms in solid crystals is now reaching the same degree of completeness as that obtained in the study of gaseous spectra.
>
> It is well known that the study of the spectra of gaseous substances gives very definite and detailed information concerning the structure of the atom in the gaseous state. It has, however, been very difficult to get any definite information regarding the solid state. For this reason the spectra of rare earth compounds obtained by Dr. Spedding are of great importance. The sharpness and amount of detail in these spectra are really quite extraordinary and the information that they are capable of giving is therefore extensive.
>
> The important contribution of Dr. Spedding has been, however, to the interpretation of such spectra. It is quite true that spectra of certain solids like this have been known in more or less extensive form for a number of years, but it is only recently that any progress has been made in their interpretation and in this work of interpretation Dr. Spedding has played a leading part.

OBITUARY

Dr. Arthur Powell Davis, consulting civil engineer, living at Oakland, California, past president of the Society of Civil Engineers and director of the

U. S. Reclamation Service from 1902 to 1920, has died at the age of seventy-two years.

MISS ELIZABETH H. SMITH, assistant plant pathologist at the University of California, was instantly killed in a traffic accident at Berkeley, California, on August 21.

PROFESSOR WILLIAM GRANT CRAIB, Regius professor of botany at the University of Aberdeen, a student of Oriental plants, died on September 1.

DR. SEBASTIAN RECASENS, formerly dean of medicine at the University of Madrid, died on August 14, aged sixty-four years.

Nature reports the following deaths: Mr. W. J. Lewis Abbott, known for his contributions to the prehistory of England and collection of flint implements, aged eighty years; Mr. H. F. Tagg, for nearly forty years keeper of the museum at the Royal Botanic Garden, Edinburgh; Dr. A. W. J. MacFadden, formerly senior medical officer in charge of the Food Department of the Ministry of Health, on August 16, aged sixty-four years, and Dr. V. H. Veley, lecturer in science in the University of Oxford in 1879–1903, joint translator of "The Handbook of the Polariscope" and author of "The Micro-Organism of Faulty Rum," on August 20, aged seventy-seven years.

SCIENTIFIC NOTES AND NEWS

DR. RUFUS COLE, director of research at the hospital of the Rockefeller Institute, received *in absentia* the honorary degree of doctor of science from the National University of Ireland, Dublin, during the recent annual meeting of the British Medical Association.

THE Elisha Kent Kane Gold Medal of the Geographical Society of Philadelphia has been awarded to Mr. Owen Lattimore in recognition of contributions to geographical knowledge in Central Asia. The results of Mr. Lattimore's explorations accomplished in a five months' camel caravan expedition from Kweihua, on the border of Mongolia, to Urumchi in Chinese Turkestan, are to be found in his book "The Desert Road to Turkestan," published in 1928 by Methuen. Subsequently Mr. and Mrs. Lattimore spent several months in explorations in western Turkestan, returning to America by way of India. Early in October Mr. Lattimore will lecture on his investigations in Manchuria and Mongolia before the Chicago Geographical Society and at the Field Museum.

IN recognition of the important assistance he has rendered to the Field Museum, Chicago, in carrying out its botanical work in the joint project with the Rockefeller Foundation, the board of trustees of the museum has elected Dr. B. P. Georges Hochreutiner, director of the Botanical Garden at Geneva, a corresponding member. This is a class of membership conferred only on scientific men or patrons of science residing in foreign countries who have rendered eminent service to the museum.

DR. MARTIN BENNO SCHMIDT, professor of pathology at Würzburg, reached his seventieth birthday on August 23.

DR. EDWARD H. KRAUS, professor of mineralogy and crystallography and dean of the College of Pharmacy at the University of Michigan, has been appointed dean of the College of Literature, Science and the Arts. Dr. Louis A. Hopkins, professor of mathematics, will succeed Dr. Kraus as head of the summer session. Dr. Howard B. Lewis, head of the department of physiological chemistry, has become dean of the College of Pharmacy.

DR. EDGAR ALLEN, formerly dean of the University of Missouri School of Medicine, takes up his work as professor of anatomy and head of the department at Yale University at the beginning of the college year. Harold Saxton Burr, professor of anatomy since 1929, Yale University School of Medicine, has been appointed E. K. Hunt professor of anatomy and head of the section of neuro-anatomy to succeed Dr. Harry Burr Ferris, who has become professor emeritus. Dr. George M. Smith has been made research associate in anatomy with the rank of associate professor. Dr. Harry M. Zimmerman, of the department, was recently promoted to an associate professorship.

PROFESSOR OTTO STERN, experimental physicist and former head of the Institute of Physical Chemistry at the University of Hamburg; his assistant, Professor I. Estermann, and Professor Ernst Berl, chemist and professor at the Technical University at Darmstadt, have joined the scientific staff of the Carnegie Institute of Technology, Pittsburgh.

RECENT promotions in the science departments at the Ohio State University include the following: Dr. Laurence H. Snyder and Dr. Clarence H. Kennedy, of the department of zoology, and Dr. Albert D. Frost, of the department of ophthalmology, from associate professors to professors; Dr. David F. Miller, of the department of zoology, Dr. E. F. Almy and Dr. R. C. Burrell, of the department of agricultural chemistry, and Dr. P. B. Stockdale and Dr. W. A. P. Graham, of the department of geology, from assistant professors to associate professors; Dr. W. H. Bennett and Dr. Harald H. Nielsen, of the department of

physics, and Dr. Frank C. Starr, of the department of dentistry, from instructors to assistant professors.

DR. GLENN G. BARTLE, of the Junior College of Kansas City, has been appointed professor of geology and head of the division of physical sciences at the newly organized University of Kansas City.

DR. J. J. WESTRA, JR., has been appointed adjunct professor of physiology at the University of Texas.

DR. R. A. WEBB has been appointed to the university chair of pathology in the school of medicine for women at the University of London.

DR. M. BORN has been appointed university lecturer in mathematics at the University of Cambridge.

DR. CHARLES F. ROOS, formerly permanent secretary of the American Association for the Advancement of Science, has been granted an indefinite furlough from fellowship by the Guggenheim Foundation to enable him to accept an appointment as specialist in economic balance for the National Recovery Administration. He assumed this office on July 27.

JOHN VAN ANTWERP MACMURRAY, director of the Walter Hines Page School of International Relations at the Johns Hopkins University, has been appointed by President Roosevelt as minister to Esthonia, Latvia and Lithuania.

FRANK F. LINDSTAEDT, who for the past seven years has been director of research for the Colloidal Products Company and the Hercules Glue Company of San Francisco, has resigned to establish in Oakland, California, a practise as consulting chemist, specializing in insecticidal and colloidal chemistry.

DR. ERNST FRÄNCKEL, professor of internal medicine at the University of Berlin, known for his research on cancer, is continuing his work in London. Westminster Hospital has placed its laboratory of pathology at his disposal.

PROFESSOR AND MRS. EINSTEIN arrived in London on September 9. According to an Associated Press dispatch he left Belgium on account of having received reports that his life was in danger from a secret German Nazi organization.

MARCHESE GUGLIELMO MARCONI will visit the United States in early October and be the guest at a celebration in his honor at the Century of Progress in Chicago. Marchese Marconi has not visited the United States since 1927, when he attended the International Radio Conference at Washington.

THE Delaware County Institute of Science, Media, Pennsylvania, will celebrate the one hundredth anniversary of its founding on September 21.

PAUL GOODLOE MCINTIRE, Charlottesville, Virginia, has given to the University of Virginia School of Medicine $75,000 for the study and treatment of mental diseases and $100,000 for the study of cancer, the latter as a memorial to his wife.

SECURITIES with a market value in excess of $300,000 have been transferred to Northwestern University Medical School by an anonymous donor, to be used for the advancement and improvement of the teaching of urology. The trustees have the right to invest this money and allocate the income to the designated purpose whenever it is considered sufficient to inaugurate a productive program.

REAR ADMIRAL RICHARD E. BYRD will leave Boston for the Antarctic on September 25. Two ships have been provided for the expedition, *The Bear* and *The Pacific Fir*. The latter will carry the supplies necessary for the whole trip, thus making possible greater economies, since all supplies are donated and foreign purchasing will be unnecessary. One of the two planes to be taken is a giant Condor, with a wing spread of eighty-two feet, capable of carrying twenty passengers. Victor Czegka, of Malden, Massachusetts, formerly chief warrant officer in the United States Marines, will be supply officer. Dr. Guy Shirey, of Texas, medical officer and member of General Bullard's staff during the war, will assist Mr. Czegka. He will also fill the post of medical officer and be in charge of the personnel. Harold I. June will serve as pilot and will have charge of aviation. Kenneth Rawson, of Chicago, will be navigation officer; his experience covers four trips in the Arctic. The engineer officer of the expedition will be Lieutenant-Commander Walter K. Queen. Captain Alan Innes-Taylor, of Canada, who will have charge of the sledging department, will also care for the 150 dogs that the expedition is taking south. Mr. Paul Siple, of Erie, Pennsylvania, will do biological work. Dr. Thomas C. Poulter, Mount Pleasant, Iowa, will go as physicist, and will carry on a study of cosmic rays. Dr. Charles Morgan, of Seminole, Texas, will go as geologist and Quinn Blackburn as surveyor. The commander of *The Bear* will be Captain Benedik Johannsen, of Trömso, Norway, a veteran of the last expedition. In charge of ice navigation will be Captain Hj. Fr. Gjertsen, of Oslo, Norway.

NORMAN E. A. HINDS, associate professor of geology at the University of California; C. E. Van Gundy, G. Vorbe and E. C. Doell, graduate students at the same institution, spent May, June and July at the Grand Canyon investigating the Algonkian formations, a research sponsored by the Carnegie Institution of Washington. Exposures of the earlier Algonkian Unkar strata in and near Bright Angel and

Clear Creek canyons and those of the later Chuar beds in Nankoweap and Kwagunt valleys on the east side of the Grand Canyon were mapped in detail. Entrance to the Nankoweap and Kwagunt area was made by a trail built sixty years ago for Major J. W. Powell and used by Dr. C. D. Walcott in 1880 when he studied the Algonkian of this district. Extensive suites of specimens were collected from both the Unkar and Chuar for laboratory studies of the sedimentary and igneous rocks. Mr. Van Gundy is now at the Grand Canyon mapping exposures of the Unkar on the south side of the Colorado River below Grand View and Desert View. Field work on the project will be continued in 1934. This work, with Noble's on the Shinumo Quadrangle, will complete the mapping and study of the Algonkian formations of the Grand Canyon. Professor Hinds and Mr. Van Gundy also examined exposures of the Mazatzal quartzite near Natural Bridge and Del Rio, central Arizona, and of the Apache group at Roosevelt Dam, near Globe and Miami, and in the Sierra Ancha to compare them with the Algonkian of the Grand Canyon.

THE Sun Yat-sen Institute for Advancement of Culture and Education, a new research institute, has been organized at Shanghai in memory of Sun Yat-sen. The following officers have been installed: *Chairman*, Board of Directors, Mr. Sun Fo (president, Legislative Yuan); *Secretary General*, Mr. Yeh Kung-cho (former Minister of Communications in Peiping and Minister of Railways in Nanking); *Directors*, Dr. Tsai Yuan-pai (president, Academia Sinica), Dr. H. H. Kung (former Minister of Industries and now president of Central Bank), General Wu Techen (mayor of Shanghai), Mr. Tai Chuan-hsien (president, Examination Yuan), Mr. Sze Liang-chai (proprietor of *Shun Pao Daily News*), Mr. Usang Ly (president, Chiaotung University) and Mr. Chen Hung-nien (former Vice-Minister of Railways, now president of Chinan University). These above directors, together with the chairman and the secretary general, form the presidium, but there are other directors besides these. The institute is divided into three departments: Research Department—director, J. Usang Ly, co-director, D. K. Lieu; Editorial Department—director, Sze Liang-chai, co-director, Chen Ping-ho; Business Department—director, Li Ta-chao, co-director, Li Ken. The National Government and the Shanghai City Government have promised to contribute monthly to the support of the institute. These two sums total $650,000 a year. At present the institute has on hand a sum of approximately $50,000. As the institute is organized in memory of Dr. Sun Yat-sen, the research program will have some bearing on his teachings, such as rural economy, proper utilization of capital, local self-government, the labor question and Chinese social psychology.

THE eighteenth annual meeting of the Optical Society of America will be held from October 19 to 21 at the Inn at Buck Hill Falls, Pennsylvania. The meeting is also open to non-members. Buck Hill Falls is in the Pocono Mountains near Stroudsburg. The inn can be reached conveniently by automobile or rail from all the principal cities of the East. It has ample accommodations for the meetings, plentiful facilities for quiet recreation, including fishing, swimming, riding, tennis and golf. At the time of the meeting the autumn coloring of the woods should be at its best. In addition to the usual program of papers contributed by members on their own initiative, the meeting will include the following special features: (1) A program of invited papers on "A Century of Photography." Announcements of the complete details will be made in the final notice of the meeting, which will be mailed early in September. It is expected that the program will include papers by eminent authorities on "The History of Photography," "The Reproduction of Tone Values," "Color Photography," "The Development of the Photographic Objective," "Color Sensitivity of Photographic Materials," "The Photographic Recording of Sound," "Photographic Photometry." (2) A group of invited papers on "The Properties of Evaporated Metal Films," a subject of timely interest in the determination of the optical constants of metals and in the production of reflecting surfaces of high efficiency in various spectral regions. (3) The presentation of the Frederic Ives Medal for 1933 to R. W. Wood, professor of experimental physics, the Johns Hopkins University, at a dinner to be given in honor of Professor Wood.

DISCUSSION

OUR COMMON NUMERALS

MILLIONS now use our common numerals daily and hence it is natural that their origin has become a subject of wide interest in this age of increasing scientific inquiries. While no universally accepted theory has yet been advanced it may be desirable to consider from time to time the latest serious efforts along this line, especially since undue confidence has frequently been expressed in the views of those who jumped at conclusions before a sufficient number of

evidences were available. A theory which differs widely from the one commonly expressed in our histories of mathematics and elsewhere but which is supported by a sufficient number of historical evidences to command the respectful attention of some who made a special study of this subject was recently published in a pamphlet of 51 pages, which appeared under the title "Die Entstehung unserer Ziffern," 1932, by V. Goldschmidt, Heidelberg, Germany.

According to this theory, our common numerals originated in Egypt and came into Europe through the western Arabs. Traces of the positional values of the digits are here supposed to appear in the hieratic writings of the ancient Egyptians whose number symbols are here regarded as the prototypes of our modern numerals. It is well known that the Arabs, who commonly used number words instead of number symbols, sometimes placed a dot above a digit to represent tens, two dots to represent hundreds, etc. V. Goldschmidt assumes that our common positional values of the digits are due to the observation that these dots could be omitted without ambiguity, in view of the fact that the relative positions of the digits are equivalent thereto. He regards the Hindu numerals as variants of the ancient Egyptian hieratic number symbols and hence gives no credit to India as regards our common numerals, while such credit ascribed to them by others has been commonly regarded as their chief claim for mathematical distinction.

This disaccord may serve to emphasize the fact that the extensive literature devoted to the consideration of evidences supporting the Hindu origin of our common numerals has not yet removed all the obstacles in the way towards establishing this theory on a firm basis. At any rate, the complacency with which many writers accepted this theory is not justified at the present time. Even in such a valuable work as Felix Klein's "Elementary Mathematics from an Advanced Standpoint," 1932, it is stated, page 80, that "the Hindus, especially, played a mathematical rôle as creators of our modern system of numerals, and later the Arabs, as its transmitters." The noted work by V. Schmidt will probably tend to create a better atmosphere for the progress of knowledge along this line, especially since other writers, including N. Bubnow, recently also tried to prove that our common numerals could not have originated in India.

G. A. Miller

University of Illinois

UNITS OF PLANT SOCIOLOGY

The long-standing confusion in phytogeographic and phytosociologic nomenclatures has been largely cleared up by certain European ecologists. Recognizing that a classification should be carried through on a single, consistent set of principles, these Europeans have sharply differentiated between the nomenclature of geographic categories and that of sociologic categories. And while phytogeographic divisions must be correlated with phytosociologic units, they are not and can not be coterminous in area or in conception or in terminology. That this is not yet fully understood is shown by the remark of a recent reviewer.[1] After naming the larger geographic units of Braun-Blanquet[2] (region, province, sector, district), Dr. Gleason remarks, "Presumably the next lower step is the community complex or the association." In other words, presumably the smallest geographic unit is a sociologic unit or entity. Braun-Blanquet gives no occasion for this presumption. In fact, that is exactly what he aims to avoid. The word "association," meaning a unit stand of vegetation, should not be regarded as a geographic term. The association is a social unit, like a "herd" of cattle or a "swarm" of bees. It occupies space, to be sure, but the name of the space is not association. We have "yards" for cattle and "hives" for bees. But no geographic term has yet been invented, so far as I know, for the ground on which an association stands. But Braun-Blanquet, accepting a suggestion from Nichols,[3] advises using the term "association" both for the concept arrived at by generalization from a number of examples, and also for each example by itself—as, he remarks, we already use the term "house."

The association of Braun-Blanquet is the smallest sociologic unit, in the same sense that the species is the smallest systematic unit. There may be subassociations, variants, etc. Each actual living example of the association is a "stand" (comparable with the individual plant of systematic botany). The association ("species"), alliance ("genus"), order ("family") and class are strictly sociologic units. Since associations occupy space, they occur in certain phytogeographic areas. The phytogeographic units are, from least to greatest, the subdistrict, district, sector, province and region.

The association of Braun-Blanquet, and of European ecologists generally, is a much smaller unit than we in America have generally considered it. It is nearer to the society or socies of Clements, but is differently (*i.e.*, quantitatively) defined. In the "oak-chestnut" forest of Long Island, of southeastern Pennsylvania and of the vicinity of Baltimore there are several associations. There is a chestnut oak associa-

[1] H. A. Gleason, Braun-Blanquet's "Plant Sociology," *Ecol.*, 14: 70–74.

[2] J. Braun-Blanquet, "Plant Sociology." Ed. and transl. by G. D. Fuller and H. S. Conard. McGraw-Hill, New York. 1932.

[3] G. E. Nichols, "A Working Basis for the Ecological Classification of Plant Communities," *Ecol.*, 4: 11–23, 154–179. 1923.

tion, a white oak association, a chestnut oak association with *Kalmia latifolia,* a black oak association, a Liriodendron association, and many moss and lichen associations. The forest as a whole may represent an alliance or order. The coastal dune region of Long Island and New Jersey has also many associations: Ammophiletum, Hudsonietum, etc. The "dune complex" is a complex of associations which can not be classed together floristically. They may be classified syngenetically (by successions, which are often highly hypothetical), or they may be grouped under such a mongrel term as "formation," meaning all the types of vegetation on a given area. Useful as such a "formation" is for some purposes, it is compounded of vegetation and land area.

The application of these ideas to the vegetation of North America will make the distinctions more clear and concrete. We may cite the great grassland area of the central United States and Canada. From the geographic standpoint this constitutes a province, which may be divided, following the map of Shantz and Zon,[4] into two sectors: the prairie (tall grass) sector and the plains (short grass) sector. The prairie sector is divisible into at least a northern district, including the eastern part of the Dakotas and western Minnesota, two central districts and a southern. The most of Iowa, with parts of Illinois, Missouri, Nebraska and Kansas, including all the rich prairie region with mild climate, may be termed the Iowa district (one of the central districts cited above). In this district several subdistricts can be clearly recognized. And if still smaller geographic units are desired, geographic terms must be invented for them.

From the sociologic standpoint Weaver and Fitzpatrick[5] and Weaver[6] have given us the most exact analysis of the prairie yet available. From their work it is plain that the associations of the prairie are several. There is at least one *Andropogonetum scoparii* (two others occur on Long Island. *Cf.* Blizzard),[7] apparently as *Andropogonetum furcati,* certainly a *Spartinetum michauxii,* apparently a Stipetum. In the Iowa prairie region there is also the *Typhetum latifoliae, Phragmitetum communis* and various Cariceta and Cypereta. Besides these, the Iowa district has many stands of Quercetum of two or three types, *Ulmetum americanae,* and many moss and lichen associations.

[4] H. L. Shantz and R. Zon. Atlas of American Agriculture, "Natural Vegetation," U. S. Department of Agriculture, Bur. Agric. Economics, 1924.

[5] J. E. Weaver and T. J. Fitzpatrick, "Ecology and Relative Importance of the Dominants of Tall Grass Prairie," *Bot. Gaz.,* 93: 113–150, 1920.

[6] J. E. Weaver, "Who's Who among the Prairie Grasses," *Ecol.,* 12: 623–632, 1931.

[7] A. W. Blizzard, "Plant Succession and Vegetational Change on High Hill, Long Island," *Ecol.,* 12: 208–231, 1931.

Geographic units and categories are essential and adequate for geographic purposes. Sociologic units and categories are wholly distinct and should be sufficient unto themselves. The recognition of these units will make possible the long-desired description and understanding of plant distribution, and thereby of animal distribution also.

HENRY S. CONARD

GRINNELL COLLEGE

ON CONCEPTS IN PHYTOSOCIOLOGY

DR. H. S. CONARD, who is largely responsible for the actual work of translating Braun-Blanquet's "Pflanzensoziologie," and to whom I am indebted for the opportunity of examining his critique in advance of its publication, is entirely correct in his statement that confusion in phytogeographic and phytosociologic nomenclature has long existed. It is also a fact that Braun-Blanquet has done much to clear up this confusion, or at least to state one view-point in such terms that one may easily grasp his meaning.

All classification is based on the grouping of individuals and the unit-individual in plant sociology is the *stand,* as numerous geobotanists have stated, as Braun-Blanquet emphasizes and as Dr. Conard reiterates. In all classifications, similar unit-individuals are brought together to form a group-unit, which in this case is the association.

Objects which have only a single character may be classified in one way only, but stands of vegetation show similarities in various characters and may be grouped in various ways accordingly. These lead to very diverse group-units, just as men may be classified according to politics, religion or occupation, resulting in each case in a different set of groups. Floristic similarity is the character chosen by Braun-Blanquet for phytosociologic classification, and in that most botanists will agree.

One must also distinguish carefully between the mental processes of classification and combination. In the former, units are grouped according to similarity and the result is an abstract concept. In the latter, units are grouped on a different basis and the result is a concrete unit of entirely different nature. Thus we classify leaves into simple and compound, opposite and alternate, depending on similarity but leading to different groups, while we combine leaves, stems and roots to make a concrete individual plant. If we classify stands of vegetation, we arrive at the association in one form or another, depending upon the character chosen as a basis. If we combine stands, we arrive at the mosaic of vegetation which covers an area. Generally speaking, we arrive first at the mosaic of a small area and by successive combinations at that of successively larger tracts. This is

precisely what Braun-Blanquet has done, so far as his results are concerned, and he has termed his concrete combinatory group-units, beginning at the most comprehensive, region, province, sector, district and subdistrict. As a matter of actual mental process, I believe his work was analytic rather than synthetic for these five upper groups. At another place in his book he mentions the association-complex as a combinatory unit, but carries his synthesis no higher and does not attempt to connect the subdistrict with the association-complex. In reviewing the book, as mentioned in Dr. Conard's first paragraph, I could only presume that the analysis and the synthesis met here, since no other intermediate group was mentioned.

Dr. Conard's statement that "association" can never be a geographic term is open to argument. He says himself that they occupy space, which would seem to entitle them to geographic standing. Elsewhere he says that the geographic unit, *Iowa prairie region,* contains associations. On the other hand, the association is a concept and as such can not occupy space. Nevertheless, the geographers certainly use as an accepted term the concept "valley," abstracted from the general characters of concrete individual valleys. It seems that one should not be too dogmatic on this point. There can, of course, be no argument on the distinctness of geographic and sociologic group-units. This distinction is a fundamental feature of Braun-Blanquet's book and is excellently illustrated by Dr. Conard.

There is a further point which needs some attention. The unit-individual of geobotany, the *stand,* is built up by successive combinations into larger and larger geographic groups to the final all-inclusive vegetation of the world. The same stands are built up by successive classifications through the higher abstract concepts of alliance, order and class to the ultimate concept—vegetation of the world. At this point the final groups are at least coextensive, although one is abstract and the other concrete.

Lastly, let me emphasize a final point. The stand, which serves at the basic unit in plant sociology, is itself a combinatory group and may be made large or smalll, according to opinion. Stands are classified into associations, according to floristic similarity, but the degree of similarity is again a matter of opinion. The nature of the association, therefore, depends on the nature of the stand and on the degree of similarity demanded. Unless a botanist has been in the field with Braun-Blanquet, seen the results of Braun-Blanquet's ratiocination demonstrated and attuned his own mental processes to exactly the same key, he has no assurance that his interpretation of associations in America corresponds with that of our Swiss colleague in the Alps. It is true that the association is in some ways comparable to the species and that either unit may be cut large or small, according to personal opinion and prevailing fashion. Within any limited region too, associations are just as valid as species. Whether this validity prevails over wide areas may be questioned, as I have elsewhere suggested.[1]

Different mills produce different qualities of flour from the same wheat. The association-concept is the product of our mental mills. What we need in plant-sociology is a mental process that gives us a standardized product, and to this end Braun-Blanquet has done very much to help us.

H. A. Gleason

New York Botanical Garden

OBSERVATIONS OF ANIMAL BEHAVIOR

It is with some misgiving that I relate the following snake story, for what I saw may be either a well-known characteristic of this species or it may seem highly improbable. While walking along a road in southern New Jersey recently, I saw a small green snake, possibly 15 inches long, wriggling on the polished roadbed without making any forward progress. After touching it with the toe of my shoe a few times, it shammed dead, as many other snakes do. Then I turned it over with my foot and, to my amazement, it kept right on rolling over and over, for all the world like a stick, although ripples passed up and down its body as though it employed the snake motion in turning or rolling over and over, sidewise—not like the alleged hoop snake. When it reached the side of the road, however, it went about its business in the usual manner, while I stood there wondering if I really had seen what I thought I saw.

C. R. Underhill

Lower Bank, N. J.

It was my good fortune to witness recently an incident in the behavior of the honey-bee which seems to me to be worthy of record. In the rear of my house is a bird bath about fifteen inches in diameter and possibly holding, when full, a body of water two inches deep in the center. Yesterday, while pulling weeds within a yard of the bath I saw one bee foundering in the center. In order to save himself he got over upon his back and floated but could not make any headway toward shore and there was no wind to move him in any direction. Presently one of the several bees drinking around the shallow rim flew out over the center, came down close to the drowning bee, and, after the two had successfully locked their feet in some way, flew vigorously toward the shore and landed his hapless mate safely.

H. R. Phalen

St. Stephens College

[1] *Bull. Torrey Club,* 53: 1–20, 1926.

REPORTS

FEDERAL ALLOTMENTS FOR PUBLIC WORKS

SECRETARY OF THE INTERIOR HAROLD L. ICKES reports as Public Works Administrator that up to August 20, $1,196,721,389 of the $3,300,000,000 public works fund had been allotted. As many of the projects are of scientific interest the data are here given in full. They are as follows:

Farm Credit Administration (statutory)	$ 100,000,000
Tennessee Valley Authority (statutory)	50,000,000
Highways (Agriculture) (statutory)	400,000,000
Naval Construction (executive order)	238,000,000
Public Works Administration (administrative)	100,000
National Recovery Administration (administrative)	630,000
Civilian Conservation Corps (executive order)	20,000,000
Civilian Conservation Corps (executive order)	20,000,000
National Arboretum (executive order)	171,638
Great Smoky National Park (executive order)	1,550,000
Subsistence Homesteads (statutory)	25,000,000
Federal Power Commission	400,000
Re-employment Service, Department of Labor	500,000
Department of Agriculture (departmental)	340,800
Agricultural Engineering	77,813
Animal Industry	549,240
Chemistry and Soils	33,919
Chemistry and Soils and Engineering	57,750
Dairy Industry	173,670
Entomology	15,150
Experiment Stations	4,950
Food and Drug Administration	70,000
Forest Highways	15,000,000
Forest Roads and Trails	10,000,000
Plant Industry	648,807
Plant Industry (erosion control nurseries)	630,000
Forest Service (physical improvements)	15,982,745
Plant Industry	2,830,000
Plant Quarantine	2,020,620
Plant Quarantine	58,050
Public Land Roads	5,000,000
Weather Bureau	20,000
Agricultural Engineering (soil erosion control)	5,000,000
Commerce Department, Coast and Geodetic Survey	2,600,000
Aeronautics	443,000
Fisheries	150,000
Fisheries (five stations)	150,000
Lighthouses	5,225,202
Navigation	30,000
Standards	100,000

Interior Department

Alaskan Railroad		$ 210,008
Alaskan Road Commission		1,096,000
Columbia Institution for the Deaf		10,000
Freedmen's Hospital		85,000
Geological Survey (physical improvements)		1,200,000
Geological Survey (surveys)		2,500,000
Howard University		948,811
Indian Affairs (physical improvements)		2,820,000
Indian Reservation Roads		4,000,000
National Park Service (physical improvements)		1,250,000
Roads and Trails		16,000,000
Reclamation		44,460,000
Boulder Canyon	$28,000,000	
Machinery	10,000,000	
Owyhee	5,000,000	
Vale	1,000,000	
Ellensburg	60,000	
Ronald	400,000	
Reclamation, Casper-Alcova		22,700,000
Grand Coulee, Columbia Basin		63,000,000
St. Elizabeth's Hospital		850,000
Virgin Islands		114,500
Additional National Park Service		6,000
Bureau of Reclamation		20,000
Department of Justice (construction)		851,000
Department of Labor (immigration)		1,344,480
Post Office (departmental)		7,600
State Department, International Commission		26,500
State Department, International Commission (U. S.–Mexico)		1,501,500
Treasury Department, Public Health Service		102,438
U. S. Marine Hospital, Staten Island		2,272,051
Supervising Architect (public buildings)		6,971,648
" " " "		11,527,499
War Department, Flood Control		1,555,000
Ordnance		6,000,000
Flood Control		7,000,000
Rivers and Harbors (upper Mississippi)		11,500,000
Corps of Engineers (seacoast defenses)		6,000,000
Rivers and Harbors		8,000
Independent Offices, Arlington Bridge Commission		200,000
National Advisory Committee for Aeronautics		200,000
Panama Canal		1,000,000

Housing Projects

Neptune Gardens, Inc., Boston	3,500,000
Spence Estate Housing Corporation, Brooklyn	2,025,000
American Federation of Full-fashioned Hosiery Workers, Philadelphia	845,000
Dick-Meyer Corporation, New York	3,210,000

Suburban Housing Association, Hutchinson, Kansas	$ 40,000
Triborough Bridge Authority, New York	44,200,000
(Loan, $37,000,000; grant, $7,200,000)	
Total	$1,196,721,389

DOCTORATES CONFERRED IN THE SCIENCES BY AMERICAN UNIVERSITIES, 1932–1933[1]

In assembling the data for the doctorates in the sciences conferred by American universities from year to year, a steady increase has been observed in the number granted, especially since 1919. The following figures for the past ten years summarize this trend: 1924, 611; 1925, 640; 1926, 748; 1927, 796; 1928, 842; 1929, 1,025; 1930, 1,074; 1931, 1,147; 1932, 1,241; 1933, 1,343.

From these totals it is seen that the so-called years of depression have had a stimulating effect upon higher education. The same fact is emphasized by the survey of graduate research students in chemistry, as shown by the statistics collected from about 130 American universities:[2] 1924, 1,700; 1925, 1,763; 1926, 1,882; 1927, 1,934; 1928, 2,081; 1929, 2,498; 1930, 2,795; 1931, 3,261; 1932, 3,348.

Each year it has seemed that the curve had reached a maximum and that the number of doctorates granted in the sciences must decrease. Apparently it is impossible at this time to predict whether this will happen, and if so, when.

This distribution of the doctorates by subjects shows no significant change last year, as compared with earlier years. The 1,343 doctorates granted in 1933 were distributed as follows: Chemistry, 417; physics, 123; zoology, 115; psychology, 101; botany, 79; mathematics, 78; engineering, 75; geology, 66; physiology, 39; agriculture and forestry, 36; bacteriology, 36; pathology, 23; anatomy, 17; entomology, 17; genetics, 15; horticulture, 15; anthropology, 13; pharmacy and pharmacology, 13; archeology, 10; astronomy, 10; geography, 10; public health, 10; medicine and surgery, 10; metallurgy, 9; paleontology, 6.

Each year there is a certain fluctuation in the number of doctorates granted by the various universities. Thus, this year Cornell showed an increase of 30 over last year, while Chicago showed a decrease of 43; Michigan showed an increase of 26, Harvard, 18, Illinois, 17, California Institute of Technology, 15, Columbia, 13, etc. These differences from year to year are really of little importance, for next year the order may be entirely different; however, a survey of the data for the past ten years shows that those universities which grant 20 or more doctorates maintain about the same relative positions from one year to another.

The following figures show the number of doctorates granted by the various universities for the academic year 1932–1933: Cornell, 110; Wisconsin, 87; Michigan, 81; Chicago, 73; Columbia, 71; Johns Hopkins, 68; Harvard, 63; Illinois, 63; California, 62; Minnesota, 62; Ohio State, 53; Yale, 50; Iowa, 48; California Institute of Technology, 36; Princeton, 32; Iowa State University, 31; Massachusetts Institute of Technology, 30; Pennsylvania, 24; New York, 21; Pittsburgh, 20; Stanford, 18; Northwestern, 17; Texas, 16; Washington University (St. Louis), 12; Duke, 11; Indiana, 11; Brown, 10; Cincinnati, 10; Maryland, 10; Pennsylvania State College, 10; Kansas, 8; Missouri, 8; Notre Dame, 7; Purdue, 7; Radcliffe, 7; Washington, 7; Catholic, 6; George Washington, 6; Nebraska, 6; North Carolina, 6; Colorado, 5; Michigan State College, 5; Rensselaer, 5; Rochester, 5; Virginia, 5; Western Reserve, 5; Clark, 4; Lawrence, 4; Rice, 3; Rutgers, 3; Vanderbilt, 3; American, 2; Boston, 2; Fordham, 2; George Peabody, 2; Oregon, 2; St. Louis, 2; Arizona, 1; Georgetown, 1; New York State College of Forestry, 1; State College of Washington, 1; Syracuse, 1; Tulane, 1.

Detailed data regarding the 1,343 doctorates granted in 1932–1933, giving the names of the recipients of the degrees and the titles of the theses, together with comparative statistics for the past ten years, will be found in *Reprint and Circular Series* of the National Research Council, No. 105. Earlier numbers of this series, containing such data for previous years, are: 26, 42, 75, 80, 86, 91, 95, 101 and 104.

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Callie Hull

[1] See Science, 72: 357 (1930), 74: 659 (1931), 76: 296 (1932) for a survey of the data on doctorates from 1898 to 1932.

[2] See *Jour. Chem. Education*, 10: 499 (1933) for further details of this study.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

A DEVICE FOR MEASURING INTENSITY OF ILLUMINATION

A timely article by Nicholas,[1] calling attention to the economies that may be effected without loss of efficiency for animal work, prompts the writers to call attention to a home-made equipment for measuring intensity of illumination, in connection with plant work, which costs less than one third the amount asked by professional supply houses for a similar equipment.

The materials consist essentially of one Weston

[1] Science, 78: 38–39, 1933.

photronic cell, a Weston galvanometer, model 440, a three-way toggle switch and small lengths of copper wire for shunts and connections. The cell is connected directly across the galvanometer, which may be shunted to give the desired range. The three-way switch will allow four ranges. It connects a shunt for each position, and the most sensitive range is obtained with the switch in the neutral or open position. Each position of the switch may be calibrated in terms of foot-candles by means of ordinary electric lamps of known candle power, at measured distances. (Incidentally, the equipment used by the writers was also calibrated against a similar one made by a professional supply house and it was found that the home-made device was fully as sensitive and showed no greater errors than the professional equipment.)

When the above-mentioned galvanometer is shunted with the proper resistance and used with the photronic cell, intensities of illumination from 10 to 15,000 foot-candles may be measured accurately and the deflection is strictly proportional to the illumination over these ranges.

This equipment, housed in a small wooden case, has been used daily in the field during the Irish potato growing season in southern Arkansas[2] for determining differences in amount of illumination, on plants variously treated, in order to ascertain the possible influence of intensity of illumination on the etiology of tip and margin burning of Irish potato leaves. The simplicity and sturdiness of the instrument, its sensitivity over a relatively wide range of illumination and ease of manipulation have commended it to the writers, aside from its relative cheapness.

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AN IMPROVEMENT OF THE CHAMBERS MICROMANIPULATOR

THE Chambers micromanipulator modified by Wright and McCoy works very well for making single cell cultures of bacteria after one manages to get the mouth of the pipette in focus of the low power objective. But much time and patience are consumed before this is accomplished. There is a coarse vertical adjustment operated by a screw, but for both horizontal movements the pipette must be manipulated by hand. The difficulty is that the pipette usually touches the side of the moist chamber before it can be centered and must be discarded for fear of contamination, if it does not break.

To provide a relatively fine adjustment for the horizontal movements, the fitting A (Fig. 1) was cut

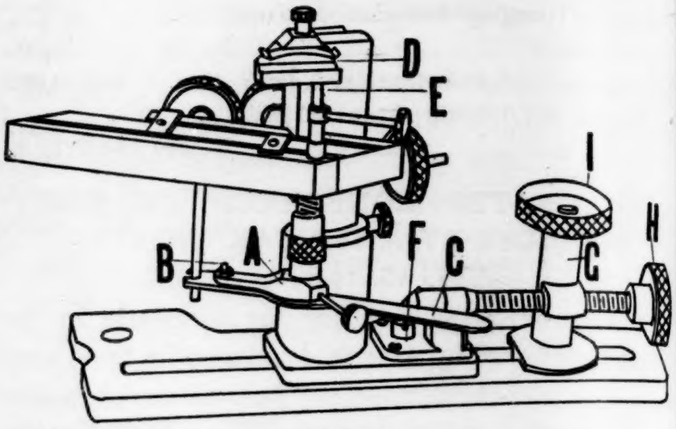

FIG. 1

off and the slotted lever C was secured to it by the bolt B and by engaging the notched end of C into the rod that extends downward from the instrument. A slot in the lever C also engages the screw head at the base of the rod E, which carries the pipette holder D. By moving the handle of the lever C back and forth, the pipette holder also moves back and forth. But its movement is limited by the slot in the lever C. This produces a limited movement of the pipette across the field (from 6 o'clock to 12 o'clock). To move the pipette from right to left, a second attachment is used. The fitting F is securely screwed into the base of the manipulator. The long screw attached to the knob H moves freely in this fitting (F), but engages a thread in the standard G. This standard (G) can be clamped to the runway at any place by turning the knob I. Then turning the knob H moves the pipette from right to left or *vice versa*.

These modifications were designed and made by Mr. Thomas McG. Aiken, of the Aiken Camera Laboratory, Pittsburgh. The writer merely explained to him the difficulties experienced.

The usual technique of blowing and sucking on a tube attached to the pipette was found too difficult by

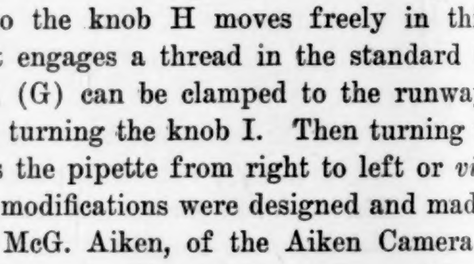

FIG. 2

[2] Fruit and Truck Branch Experiment Station, Hope, Arkansas.

the writer when the mouth of the pipette is small. It also seems to be a contributory factor in the causation of colds, possibly due to the effort and the contamination of the old saliva. Pressure and suction can be applied and regulated by the device shown in Fig. 2. A well of mercury (A) is attached to the pipette by the T-tube B mounted in a block of wood. The tube holding the spring clamp D leads to the pipette; the tube holding clamp E to the air. When pressure is desired, the bulb C is raised by pressing a foot treadle and the clamp D is opened. When suction is desired, the spring clamp E is opened and the bulb C is raised until the well A is nearly full of mercury. Then the clamp E is closed, the bulb C is dropped and suction is applied to the pipette by opening the clamp D.

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SPECIAL ARTICLES

INSECT TRANSMISSION EXPERIMENTS WITH HERPESENCEPHALITIS VIRUS[1]

THE recent demonstration by Kelser of the fact that the virus of equine-encephalomyelitis can be transmitted by *Aedes aegypti* suggested the possibility that some of the other neurotropic filterable viruses might likewise be transmissible either through this mosquito or through other species of insects. Also, in spite of the present uncertainty as to the etiological relationship between such viruses and epidemic human encephalitis, it was believed that insect transmission experiments might add to our limited information concerning the methods by which this disease is spread.

With this possibility in mind preliminary experiments were begun in April, 1933, using a laboratory-bred strain of *Aedes aegypti* and several neurotropic viruses including (a) the well-known E1–1–Perdrau strain of herpes-encephalitis virus isolated in 1925 from a human case of encephalitis, (b) a virus designated as "W," more recently isolated from an acute fatal human case of ascending paralysis, and (c) the Le Fevre strain of herpes virus originally isolated from a case of herpes genitalis. For the first two viruses we are indebted to Dr. F. P. Gay and Dr. M. Holden, of Columbia University, and for the other to Dr. E. B. McKinley, of George Washington University.

The various mosquito-transmission experiments have conformed to the following general plan: (1) An infective dose of the tissue containing the virus was inoculated into one or more normal animals. (2) On each succeeding day of the test these animals were immobilized and placed in a sterilized feeding cage containing 50 to 100 normal female *Aedes aegypti*. At the end of the feeding period all mosquitoes which failed to ingest blood were caught and destroyed; those remaining in the cage were counted, given a lot number and reserved for the transmission tests. (3) After arbitrarily selected intervals, ranging from 5 to 55 days, the potentially infected mosquitoes of each lot were tested by allowing them to feed on normal animals. These feeding tests were carried out in clean rooms never previously used for virus experiments; after being bitten, each test animal was placed in a sterilized cage and isolated throughout the entire period of its observation. (4) When an animal died the brain and in some instances the spinal cord was removed as soon as possible. Half of the brain was fixed in Zenker's solution or in formalin and prepared for histological study; a portion of the remaining half was used for transfer to other animals by subdural or intracutaneous inoculation; and the rest of the brain was preserved in 50 per cent. glycerin at 5° C.

At the present stage of the investigation we are unable to draw definite conclusions as to the transmissibility of these three viruses by *Aedes aegypti*. However, some of the results strongly suggest that this may have occurred; and it is to certain of these observations that we wish to call attention in this brief progress note.

The results obtained in one experiment with the E1–1–Perdrau virus are indicated diagrammatically in Chart I. On April 6 infective amounts of the virus were inoculated subdurally and intracutaneously into two normal rabbits (R–1 and R–2); both of which died 4 days later. Forty-eight and 72 hours after inoculation, normal *A. aegypti* were fed on both animals and these mosquitoes were designated as Lots 1B and 2B, respectively. The *A. aegypti* of Lot 1B, which had ingested blood of the inoculated rabbits at the end of 48 hours, were first tested on April 14, when five mosquitoes bit a normal rabbit (R–384), and again on April 21, when six fed on another (R–396). Both animals died; the former after 50 days and the latter after 16 days. Histological sections of the brain from one animal (R–384) were negative, while those from the other (R–396) contained lesions characteristic of encephalitis. Transfer of a suspension of the fresh brain of R–384, by intracutaneous inoculation into a normal rabbit (R–495) was followed by death 10 days later; and transfer of brain from R–396 to four normal rabbits (R–416,

[1] A preliminary note.

R–417, R–456 and R–457) was followed by the death of two of these animals after 17 and 32 days, respectively. The histological reports on the three animals which succumbed were negative.

The Lot 2B mosquitoes which had ingested blood from the inoculated rabbits at the end of 72 hours were tested on April 15, when seven bit a normal rabbit (R–390); on April 17, when four bit another (R–386); and again on April 24, when eight fed on a third normal rabbit (R–406). These test rabbits died after intervals of 12, 39 and 31 days, respectively; and one of them (R–390) became paralyzed in the hind legs six days before death. Histological examination of the brain of one of them (R–406) was negative. Suspensions of brain from each of these three animals were inoculated into normal rabbits. In a group of three animals which received the brain of R–390, one is alive, while two died after 36 and 65 days, respectively, and the histological examinations indicate that one of these had encephalitis. Of the three rabbits inoculated with the brain of R–386, two died after intervals of 76 and 17 days, and one of these was paralyzed nine days before death. The histological examination of the paralyzed animal has not been completed, but the brain of the other showed lesions of encephalitis. In the third group of rabbits, which was inoculated with brain from R–406, two lived and one died after an interval of 14 days; but no pathological lesions were found in the brain.

In addition to the feeding experiments outlined above, the *A. aegypti* of Lots 1B and 2B were tested for infectivity on April 26, by macerating in saline two mosquitoes from each lot, and injecting this suspension intracutaneously into a normal rabbit (R–408). This animal became paralyzed after 33 days and died on the 35th day. Histological examination of the brain was negative, but transfer of a saline suspension of the fresh brain by intracutaneous inoculation into another rabbit (R–491) was likewise followed by paralysis after 12 days and by death on the 14th day. The histological report on this animal was negative.

Thus, of the six rabbits used in testing the mosquitoes of Lots 1B and 2B, all died after periods of 12 to 50 days; and two were paralyzed before death. The brains of four animals have been examined histologically, and one of these showed the lesions of encephalitis. Of the fifteen animals inoculated with suspensions of brain tissue obtained from the mosquito-test rabbits, nine died after 10 to 76 days, two were paralyzed before death, and of the eight which have been examined histologically two showed lesions of encephalitis. It is of interest to note here that of

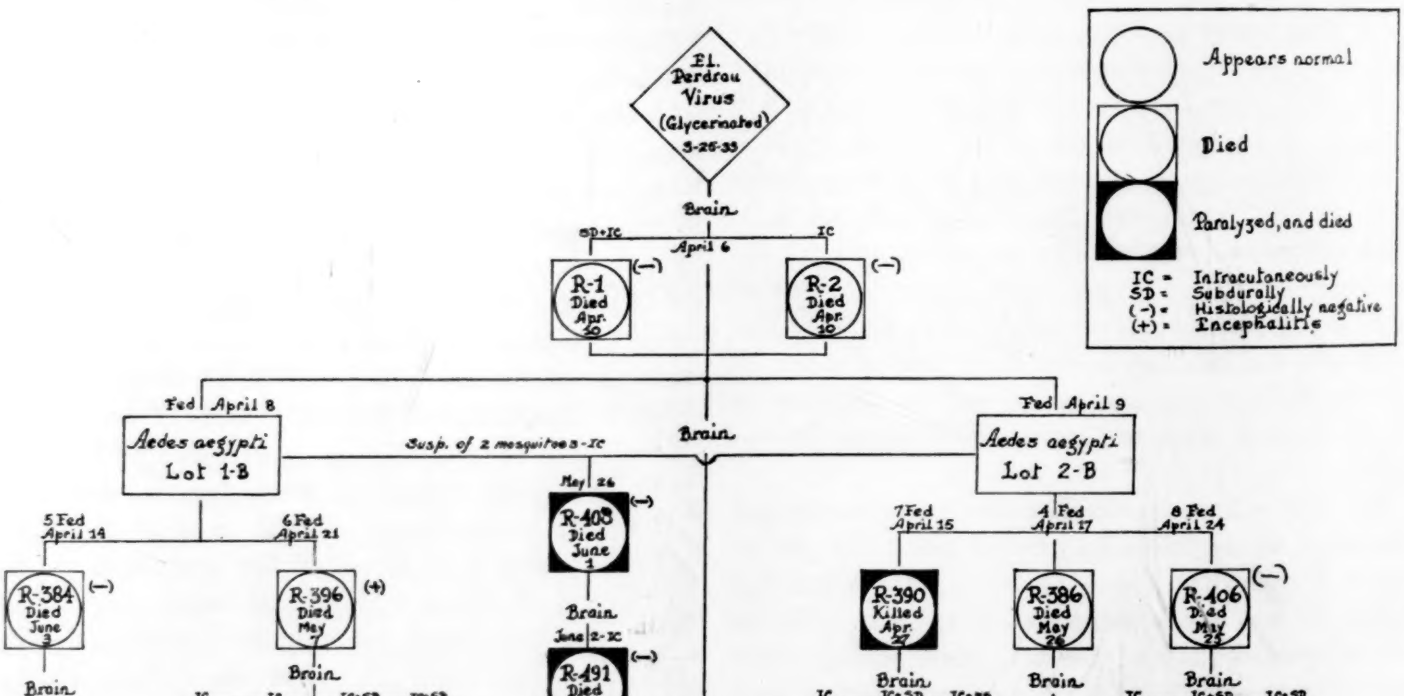

CHART I

seven rabbits inoculated either subdurally or intracutaneously with material known to contain original virus, all died after periods of 3 to 64 days; only one was paralyzed, and lesions of encephalitis were found in brain sections in only one, although all have been examined histologically.

In a second transmission experiment, begun on June 5, the Perdrau virus was inoculated subdurally and intracutaneously into three rabbits, which died after 3, 4 and 6 days, respectively. Large groups of normal *A. aegypti* fed on one or more of these rabbits 1, 2, 3, 4 and 5 days after inoculation, respectively, and mosquitoes of each of these lots were tested on normal rabbits after intervals of 8, 16 and 24 days. A total of 33 rabbits were bitten, of which 19 died after four to fifty-five days. None of these showed signs of paralysis. Brain sections have been examined from 16 of these animals and in two of these the diagnosis was encephalitis. Brain suspensions from the 19 mosquito-test animals were inoculated into 19 normal rabbits, of which 10 died after intervals of 2 to 11 days; while the remaining 9 are still being observed. Brain sections from four of these animals were negative in three instances but showed lesions of encephalitis in one. The mosquitoes used in this experiment (lots 1F to 5F inclusive) were again tested on August 22, when 470 of them fed on a normal monkey (*Cebus capucinus* No. 2). This animal showed no elevation of temperature and no paralysis, but died six days later on August 28. Brain sections of this monkey show lesions of encephalitis.

The Le Fevre virus has been used in two experiments. In one begun on April 1 the virus was inoculated subdurally and intracutaneously into three guinea pigs, two of which died 25 and 29 days later. At intervals of 2, 3, 4, 5, 6, 7, 8, 9 and 10 days following the inoculations, these three animals were exposed to groups of normal *A. aegypti*. The nine lots of mosquitoes were tested after intervals of 7 to 55 days by allowing them to feed on normal rabbits. Of the 15 animals bitten 14 died after periods of 11 to 50 days; and five were paralyzed before death. Brain sections from four of these rabbits have been examined, and in two there was evidence of encephalitis. Suspensions of brain tissue from the mosquito-test animals were transferred to 37 rabbits, of which 28 died after intervals of 6 to 71 days, and 6 of these were paralyzed before death. Five of six brains examined were negative and one was positive for encephalitis.

The second experiment with Le Fevre virus was begun on May 29, when the original virus was inoculated subdurally and intracutaneously into 3 normal rabbits, one of which died 13 days later, and brain sections show lesions of encephalitis. It appears that at least one of the survivors (R–477) was also infected, since a series of animals inoculated with 0.5 cc amounts of its blood drawn on successive days indicated that virus was present on the 1st, 2nd, 3rd, 7th and 9th days. The other two inoculated rabbits (R–471 and R–483) were exposed to large groups of mosquitoes at the end of 2, 3 and 4 days; and these 4 mosquito lots were each tested by feeding on 2 normal rabbits after intervals of 8, 16 and 24 days. Of the 27 animals bitten in these tests, 24 died after periods of from 5 to 64 days; and of these none was paralyzed. Sections of brain were examined from 23 of these mosquito-test rabbits, of which 20 were negative and 3 showed lesions of encephalitis. Suspensions of brain from the mosquito-test animals were inoculated into 24 normal rabbits, of which 19 have died within 2 to 24 days, and 2 of these were paralyzed before death. Brain sections from 10 of these were negative and one showed lesions of encephalitis.

The four lots of *A. aegypti* were again tested on August 23, when 377 mosquitoes bit a normal monkey (*Cebus capucinus* No. 3). At the time of this report the monkey is moribund and will be killed for further study.

The "W" virus, which has been used in only one transmission experiment on May 4, is unique in that following intracutaneous injection into rabbits it usually causes a paralysis of the extremities, followed by death on or about the eighth day. However, on histological examination of brain sections from 4 so infected, three have shown no lesions and the other contained lesions which were considered as suspicious but not diagnostic. Two normal rabbits were inoculated intracutaneously with this virus, and were later bitten by groups of normal *A. aegypti* after intervals of 1, 2, 3, 4, 5, 6, 7 and 8 days, respectively. The mosquitoes of each lot were tested by feeding on normal rabbits at the end of 7 days and again after 12 to 14 days. Of the 16 rabbits bitten, 11 died within 5 to 71 days, and none was paralyzed. Brain sections from only four rabbits have been examined, three being negative and one positive for encephalitis. Suspensions of brain have been transferred intracutaneously to 9 normal rabbits, of which 3 died within 3 to 33 days, and one was paralyzed before death. The brain sections from two rabbits have been examined histologically; one was negative and the other positive for encephalitis. The eight lots of mosquitoes were again tested on June 1, when a total of 90 bit a Cebus monkey (*Cebus capucinus* No. 1). This animal's temperature rose to 104 or more on the 11th and 21st days after the test, but otherwise it appeared normal until August 4, when it suddenly became weak, refused food and drink, was unable to raise its right arm above its head, and soon appeared to be moribund. X-ray examination failed to show any evidence of fracture or dislocation. Histologi-

TABLE 1

RESULTS OF TRANSMISSION EXPERIMENTS WITH NEUROTROPIC VIRUSES

Preliminary Summary

Viruses			El-1-Perdrau		Le Fevre		"W"	Total
I. Rabbits inoculated with original virus			7		9		5	21
Fatalities	Number of deaths		7		6		5	18
	Period of survival (days)		3–64		9–54		8–9	
	Paralysis		1		1		5	7
	Histological examination of brain	Not completed	0		0		1	1
		Negative	6		1		3	10
		Encephalitis	1		5		1(?)	7
II. Test rabbits bitten by potentially infected mosquitoes			Exp. 1	Exp. 2	Exp. 1	Exp. 2		
			6	33	15	27	16	97
Fatalities	Number of deaths		6	19	14	24	11	74
	Period of survival (days)		15–50	4–55	11–50	5–64	5–71	
	Paralysis		2	0	5	0	0	7
	Histological examination of brain	Not completed	2	3	10	1	7	23
		Negative	3	14	2	20	3	42
		Encephalitis	1	2	2	3	1	9
III. Rabbits inoculated with brain material from the test rabbits (II)			15	19	37	24	9	104
Fatalities	Number of deaths		9	10	28	19	3	69
	Period of survival (days)		10–76	2–11	6–71	2–24	3–33	
	Paralysis		2	0	6	2	1	11
	Histological examination of brain	Not completed	1	6	22	8	1	38
		Negative	6	3	5	10	1	25
		Encephalitis	2	1	1	1	1	6

cally the sections of brain and spinal cord were negative. Specimens of blood collected before death and suspensions of brain have been inoculated into normal rabbits, some of which have died and are now being studied.

In conclusion we wish to reemphasize the fact that the studies outlined in this report are not yet complete; and that additional work will be necessary to determine whether or not the tissues of those animals which died after being bitten by the test mosquitoes contain the specific viruses with which the respective experiments were initiated. It is also considered possible that, as in all extensive experiments with rabbits, some of the animals may have died of unrecognized extraneous causes. However, a large number of untreated control rabbits were observed during this period and only a few of these died with diarrhea, none of them showing paralysis. *Encephalitozoon cuniculi* was not found in the brain sections of any of the experimental animals.

As indicated in Table 1, irregular results were obtained with the rabbits of Group II which were bitten by the test mosquitoes, and this was also true of the animals in Group III which had received brain inoculations from the Group II rabbits. However, taken as a whole, they do not differ greatly from the results obtained in the rabbits of Group I, which were inoculated directly with the original viruses.

In view of the incidence of death and paralysis among the experimental animals, and particularly because of the nine rabbits and one monkey which showed the histological lesions of encephalitis after being bitten by the mosquitoes, we feel that the work already done strongly indicates that the viruses used have been transmitted by *A. aegypti,* but that further investigation is required to furnish absolute proof.

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RAYMOND A. KELSER
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BOOKS RECEIVED

CHAMBERLIN, ROLLIN T. and PAUL MACCLINTOCK. *College Text-Book of Geology:* Part I: *Geologic Processes and Their Results.* Second edition, revised. Pp. xi + 445. Holt. $3.00.

CHANT, C. A. and E. F. BURTON. *Text-Book of College Physics.* Pp. xiv + 541. 574 figures. Holt. $3.25.

HATFIELD, H. STAFFORD. *The Inventor and His World.* Pp. v + 269. Dutton. $2.40.

[2] With the technical assistance of Staff Sergeants George F. Luippold and Jesse F. Rhodes, Medical Department, U. S. Army.